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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2002951397 for a patent by SHIELDLINER CO LIMITED as filed on 02 September 2002.

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Tenth day of September 2003

JONNE YABSLEY
<u>TEAM LEADER EXAMINATION</u>
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ORIGINAL

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Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Apparatus for and Method of Lining Conduits"

The invention is described in the following statement:

"Apparatus for and Method of Lining Conduits"

Field of the Invention

This invention relates to an apparatus for, and a method of, lining ducts and other conduits.

The invention has been devised particularly, although not solely, for internally lining fluid flow conduits and is applicable to both gravity flow pipes, such as sewer and stormwater drainage, and pressurized systems such as water and gas pipes.

The invention is applicable to the renovation of existing pipelines and other conduits in various states of deterioration, from impaired hydraulic performance to partial or complete loss of structural integrity with a total failure to contain the fluids within or stop the ingression of fluids from without the pipe.

Background Art

Throughout the world, there are numerous pipelines which are approaching or have exceeded their service life, have been installed in extreme environments or were incorrectly installed. Consequently, they have deteriorated to an extent that remedial action is required in order to maintain the effectiveness of the pipeline or to avoid leakage. This is particularly so for municipal infrastructure involving pipe networks such as sewers and water mains using materials such as vitrified clay (VC) and reinforced concrete (RC). Typical structural problems with such gravity flow pipes include cracking or poor jointing leading to water ingress, sewage egress, root intrusion or calcification build-up on the pipe walls. The structural problems include longitudinal cracking and circumferential cracking, leading to ovality or partial collapse of the pipe.

Systems used for the renovation of such conduits generally fall within three broad categories. The traditional methods include manually applied liners and cover shotcrete, grouting and placed thermoplastic liners. The second category

includes placed thermoplastic liners installed automatically, using materials such as uPVC and HDPE and cover mechanically or thermally expanding the thermoplastic liner against the conduit wall. The third category involves the placement of generally thermoset or catalysed or UV radiation energy cured liners which are typically placed through the eversion of an already resin impregnated "sock" generally of fibreglass materials. A newer system employs a resin coating on the surface of a flexible tube of aligned polypropylene fibres. The resin on the surface is, upon eversion, forced into the sides of the pipe, the objective being the creation of a bonded liner to the pipe. This does not in practice provide a successful consistent bonded liner as the requirements for the resin layer or thickness varies dependent upon the holes and cracks as well as other requirements for the use of the resin in the pipe.

One proposal to line existing pipelines is disclosed in US Patent 4,687,677 (Jonasson). The proposal involves introduction of a flexible hose-shaped liner containing a curable plastic material into the pipeline to be lined. The flexible liner is introduced into the pipeline in an uncured state and is pressed out against the inside of the pipeline by means of compressed air. The flexible liner is then hardened in place by exposing the curable thermoset resin material to radiation energy. A somewhat similar proposal is disclosed in WO 92/16784 (Lundmark). In this latter proposal, the hose-shaped liner is introduced into the pipeline by either drawing in the liner or by everting the liner into the pipeline.

A disadvantage of such proposals involving installation of a liner which contains a curable resin material and which can be cured upon exposure to radiation energy or heat is that the liner must be manufactured, prepared and stored under fully-controlled conditions at a production facility remote from the installation site and then transported to the installation site. In addition to the transport storage and handling costs involved with storing the liners, there is also the wastage caused by premature curing of the liners in storage. Further, if premature curing is not detected prior to installation, there is the cost of removing the failed liner and commencing the installation again with a new liner. This can contribute significantly to the cost of a pipe lining operation.

There have been various proposals for lining conduits involving installation of a liner as a tube which is everted into the passageway being lined, and which comprises an inner layer of resin absorbent material surrounded by a membrane. As the tube is everted, uncured resin is applied to the everting face of the tube to impregnate the layer of resin absorbent material which is then presented to the surface of the passageway. The everted tube is held in place by fluid pressure until the resin cures to form a rigid lining on the passageway surface. One such proposal is described in GB 1512035.

With lining proposals involving eversion of a tube comprising a layer of resin absorbent material, it is most important for there to be effective impregnation of the resin absorbent material. EP 0 082 212 attempts to address this need by provision of a vacuum inside the tube in order to remove air from the resin absorbent material at the everting face so that such material is in an optimum condition to receive the resin presented to it, thereby ensuring effective penetration of the resin into the absorbent material. However, the method outlined of providing the application of vacuum to the tube is a cumbersome procedure, involving positioning of a vacuum pipe within the tube when it is in a collapsed condition prior to eversion.

Additionally, the resin is presented to the everting face of the tube in the form of a large plug of uncured resin in the passageway to which back pressure is applied. This is employed to support the plug of resin and drive the plug, and the seal within the pipe, forward. Consequently, it is necessary for the everting tube to push the plug of uncured resin along the passageway, with the result that the plug of uncured resin can be under high and variable pressure. The fact that the plug of resin is under high variable and uncontrolled pressure can cause difficulties, one being that ongoing delivery of replenishment resin to the plug can be complicated. Further, as there is no monitoring present, there is no knowledge of the size or consistency of the volume of resin. In particular, there is no feed back to determine if the volume trapped between the everting tube and the seal is air or resin. Also, with an uncontrolled resin "plug", the air that becomes trapped in the resin volume cannot escape.

It is against this background, and the problems and difficulties associated therewith, that the present invention has been developed.

The reference to prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

Disclosure of the Invention

According to one aspect of the present invention there is provided apparatus for lining the internal surface of a conduit comprising a body adapted to be progressively moved along the conduit for installing a flexible liner onto the interior surface of the conduit or any substrate applied thereto, the flexible liner comprising a tube undergoing eversion within the conduit, the body presenting a contact surface against which the tube acts during eversion thereof, the contact surface having means for delivery of resin to the everting portion of the tube.

The means for delivery of resin may include a plurality of ports in the contact surface, the ports communicating with a supply of resin.

The contact surface may be defined by a plate having apertures therein incorporating the ports.

The plate may have one face thereof defining the contact surface and an opposed face which provides a boundary for a resin chamber from which resin may be delivered to the contact face by way of the apertures therein. This also assists in the rapid and controllable release of any air trapped within the liner. As the air is purged from the highest point within the chamber all the conduit is filled with resin.

With this arrangement, the pressure exerted by the everting tube is exerted on the contact surface and not onto the resin itself and not in particular on the resin contained within the resin chamber. Consequently, the resin can freely flow into contact with the everting tube and can be easily replenished by delivery of

replenishment resin to the resin chamber. In this embodiment the resin pressure remains constant and can thus be controlled through a controlled feed back to resin delivery pumps located typically at a control station at ground level. Typically, replenishment resin is delivered to the resin chamber on a continuous basis during eversion of the tube and is controlled with a feed back loop to control feed rate of the everting tube and resin pressure for consistent progress along the conduit.

Preferably, the body also has provision for applying resin to the surface onto which the liner is presented. As alluded to earlier, the surface to which the liner is presented may comprise the interior surface of the passageway or a substrate applied to the interior surface of the passageway.

In this regard, the body may comprise a circumferential chamber which is exposed to the surface and which contains resin which is wiped on the surface. Where the passageway is of circular cross-section, the circumferential chamber is typically of annular configuration.

Preferably, the circumferential chamber is defined between two spaced apart wiper seals for sliding and sealing contact with the surface, and an inner wall extending between the two seals. The outer periphery of the chamber is essentially defined by the surface to which the resin is applied.

The inner wall may be defined by a flexible membrane. The membrane may be deflected for the purposes or pressurising the resin contents within the chamber. Alternatively and/or additionally, the flexible membrane may be vibrated in order to optimise contact of the resin with the surface.

The body may further comprise one or more additional chambers one adjacent another axially spaced along the body.

Each additional chamber may be defined by two wiper seals and an inner wall extending therebetween.

Where there are adjacent chambers, one wiper seal may be common to both of the chambers. In other words, where there are two chambers one leading another with respect to the direction of travel of the body, one wiper seal may function as the trailing seal for one chamber and the leading seal for the other chamber.

Where there are a multitude of chambers, at least some of the chambers may be utilised for the purpose of applying resin to the surface receiving the liner. In such a case, the chambers preferably operate at progressively decreasing fluid pressures in the direction away from the everting tube.

The wiper seals not only perform a sealing function but also function as wiper applicators for applying the resin in a uniform fashion to the surface.

They also form sealed pressurised chambers between which a differential of pressure can be achieved and maintained, with the highest pressure being exerted in the last chamber wetting the everting tube and the lowest in the first chamber. In this way purge lines from the rear chamber can exhaust into the front chamber driven by the differential in pressure.

In certain circumstances, it may be beneficial to apply a substrate to the conduit prior to the placement of the liner. Such substrates may include repair and/or sealing compounds (eg cementitious or polymer grout) or a layer of material for enhancing the engagement of the liner with the conduit or the filling of the surface of the inside of the conduit.

The substrate substance can be applied in the same pass as the placement of the everting tube. Alternatively, the process may involve placement of the substrate substance first with a removable or sacrificial liner that inflates to hold the substrate substance into position whilst it hardens. Then during a second pass the everting tube can be added once the substrate substance has hardened enough to absorb the water and provide a dry surface to allow the resin to cure to it.

Where a substrate is to be applied to the interior surface of the conduit, at least one of the circumferential chambers may be utilised for such a purpose. The or each chamber concerned would be adapted to receive the substrate substance. The substrate substance would be applied to the interior surface of the conduit in a similar fashion to the manner in which resin is applied; that is, the substrate substance would be presented to and wiped onto the internal surface of the passageway. Obviously, the or each chamber utilised in the installation of the substrate would be ahead of the chambers utilised in the delivery of resin for the purposes of bonding the liner into position.

Again, the substrate material may be vibrated to optimise deposition of the material onto the interior surface of the conduit.

The body may incorporate a leading section for performing preparatory work on the interior surface of the passageway in order to properly prepare it to receive the substrate substance or resin as the case may be. The leading section may include circumferential brush devices adapted to brush the side wall of the passageway.

There may be a plurality of the brush devices axially spaced one with respect to another to form air pressure chambers therebetween. A differential pressure gradient may exist between the chambers such that a pressure flow is generated from rear most chamber to front most chamber.

The forward portion of the apparatus in the preferred embodiment may also incorporate a collection means for collecting debris within the passageway prior to installation of the liner. The collection means may comprise a suction system for collecting the debris.

Preferably, the tube is delivered to the body in a collapsed condition. With this arrangement, the collapsed tube is preferably opened during the eversion process.

The body may be provided with means to establish a "wet-out" region within the collapsed tube prior to eversion thereof for the purposes of increasing the effectiveness of resin penetration.

This may involve a lance structure projecting outwardly of the contact surface and terminating at a free end, with the collapsed tube embracing the lance structure so that the lance structure is inserted in the tube as it approaches the contact face for eversion thereagainst.

The free end of the lance structure may be configured to spread the collapsed wall of the tube to create a cavity to receive the resin.

To do this reliably it is preferred to further include means to monitor and/or control the speed of progress of the lining tool and the volume/thickness of resin applied to the conduit and the everting tube. Such means may be part as a quality control system upon which the body may react, or communicate to a remote operator who may provide remote control or through a remote feed back loop to the pressure control to the pumps and the liner pull to vary the speed of advance. This can also control the feed pressure for the resin injection into the everting tube and the inflation pressure of the pressure chamber and the tube as well as the vacuum on the tube. In this way, the apparatus can be self controlling to ensure the optimum rate of progress is maintained. This can then be plotted and the plot provided to the customer.

In another preferred embodiment, the apparatus may further include a temperature measurement device for monitoring the temperature of the conduit/liner which may be in communication with a remote operator. There may also be a feed back loop with the resin supply to control the amount of catalyst to resin ratio to suit it to the temperature and conditions within the pipe. This may also form part of the quality control system.

Preferably, the apparatus further includes means for sensing and/or monitoring selected conditions associated with installation of the liner and varying the installation process as necessary having regard to such conditions. Such conditions may include the delivery rate and composition of the resin, loadings on the everting tube and the surface condition of the conduit.

According to a further aspect of the invention there is provided a method of lining conduits utilising apparatus according to the first aspect of the invention.

According to a third aspect of the present invention there is provided a method of lining a conduit comprising: providing a tube as a liner for the conduit, everting the tube into the conduit whereby the tube has an inner tube portion, an outer tube portion and an everting portion extending between the inner and outer tube portions; causing the exposed face of the everting portion of the tube to slidably engage a contact surface at which a curable resin is presented to the everting face for impregnation thereof.

Preferably, the method further comprises sensing and/or monitoring selected conditions associated with installation of the liner and varying the installation process as necessary in response to such conditions.

Brief Description of the Drawings

The invention will be better understood by reference to the following description of several specific embodiments thereof as shown in the accompanying drawings in which:

Figure 1 is a schematic sectional view of apparatus according to a first embodiment in operation installing of a liner in a pipeline;

Figure 2 is a fragmentary sectional side view of the apparatus installing the liner in the pipeline;

Figure 3 is a fragmentary perspective view of the apparatus installing the liner in the pipeline;

Figure 4 is a fragmentary sectional view of the trailing end of the installation head;

Figure 5 is a fragmentary sectional view of an intermediate part of the installation head;

Figure 6 is a fragmentary sectional view of the leading part of the installation head;

Figure 7 is a fragmentary sectional side view illustrating a wiper seal forming part of the installation head, with the wiper seal being shown in a normal condition;

Figure 8 is a view similar to Figure 7 with the exception that the wiper seal is shown in a deflected condition;

Figure 9 is a fragmentary sectional view of the trailing end of an installation head of apparatus according to a second embodiment;

Figure 10 is a fragmentary sectional view of the trailing end of the installation head of apparatus according to a third embodiment;

Figure 11 is a fragmentary sectional side view of the trailing end of the installation head of apparatus according to a fourth embodiment; and

Figure 12 is a view somewhat similar to Figure 11 with the exception that a suction line within the installation head is shown in an extended condition.

Best Mode(s) for Carrying Out the Invention

Referring to Figures 1 to 8 of the accompanying drawings, there is shown apparatus 10 according to a first embodiment for installing a liner 11 onto the interior surface 13 of a pipeline 15. The liner 11 provides a hermetically sealed barrier that is resistant to both corrosion and wear.

In this embodiment, the liner 11 is in the form of an everted tube 17. Prior to eversion, the tube 17 comprises a first layer of a resin absorbent material such as fibreglass fabric, and a second layer 19 prior to eversion of the tube 17, the first layer is innermost and the second layer is outermost to provide a lining around the first (inner) layer. The second (outer) layer is selected according to the demands placed on the liner 11 within the pipeline 15. For example, where abrasion and wear resistance is required, the second layer may be formed of polypropylene. In other cases, the second layer 19 may be formed of polyester (Mylar), nylon urethane rubber or other material appropriate for the intended application.

Upon eversion, the first layer is turned outwardly and presented to the interior surface 13 of the pipeline 15. As will be explained in detail later, a curable resin is applied to the first layer prior to its application onto the interior surface 13 of the pipeline 15. An inflation fluid is delivered into the interior 20 of the everted portion of the tube 17 to maintain the tube in intimate contact with the interior surface 13 of the pipeline 15 until the resin has cured, whereupon the resin and fibreglass fabric combine to provide a rigid composite structure which lines the pipeline 15, with the second layer being on the inner face of the composite structure and in contact with subsequent fluid flow along the pipeline.

The apparatus 10 comprises an installation head 21 which is movable along the passageway and which includes a body 23. The installation head 21 is adapted to be progressively moved along the pipeline 15 during installation of the liner.

The body 23 has a leading end 27 and a trailing end 29. In this embodiment, the body 23 is adapted to be pulled through the pipeline 15 by way of a tow line (not shown) connected to the leading end 27 and extending to a station (not shown) located exteriorly of the pipeline.

The tube 17 is delivered to, and pulled along, the pipeline 15 in a flattened or collapsed condition and is everted from that condition, as best seen in Figure 1 of the drawings. In the flattened or collapsed condition, the tube has two opposed longitudinal side portions 18, 19 and folds (not shown) therebetween. With eversion of the tube 17, there is created an inner tube portion 31 and an outer tube portion 32, with the two portions 31, 32 being joined by the everting portion 33.

One end of the tube 17 is attached to a rigid installation duct 34 positioned adjacent the inlet end of the pipeline 15. Typically, the tube 17 is connected to one end of the duct 34 by way of a clamping collar (not shown) which extends around the tube and sealingly connects it to the end of the duct.

A delivery duct 35 extends between the installation duct 34 and a delivery structure 37 which incorporates a delivery chamber 39. The delivery duct 35 comprises a flexible hose structure which is inflated to provide the duct. An inflation chamber 41 is created through the combination of the interior 20 of the everted tube 17, the installation duct 34, the delivery duct 35 and the delivery chamber 39. An inflation fluid (such as air) is introduced into the inflation chamber 41 so as to urge the everted tube 17 outwardly in order to position it in contact with the interior surface 13 of the pipe 15 to which it is bonded while the resin applied thereto sets.

The inflation fluid is introduced into the inflation chamber 41 by way of the delivery chamber 39 at the inlet end of the duct 35. The delivery chamber 39 is defined by a housing 43 having an entry end 45 and an outlet end 47 which communicates with the duct 35. The entry end 45 of the delivery chamber 39 is closed to maintain inflation pressure in the chamber, there being provided a fluid

seal mechanism 49 in the entry end 45 to allow entry of the collapsed tube. The fluid seal mechanism 49 comprises a pair of sealing rollers 51 positioned in side-by-side relationship to receive the collapsed tube structure therebetween.

The inflation pressure causes the tube 17 to evert as the installation head 21 moves along the pipeline 15.

The installation head 21 has a contact face 63 at the trailing end thereof against which the tube 17 everts. The contact face 63 is configured to conform to, and guide, the everting portion 33 of the tube 17 as it turns between the inner tube portion 31 and the outer tube portion 32. The contact face 63 is defined by a pressure plate 65. A resin chamber 67 is located in the body 23 adjacent the pressure plate 65. The pressure plate 65 provides a boundary for the resin chamber 67 and separates the resin chamber from the everting tube 17. Resin delivery lines 69 are provided for delivering resin from a source (not shown) to the resin chamber 67.

A plurality of apertures 71 are provided in the pressure plate 65, the apertures 71 extending from the resin chamber 67 and opening onto the contact face 63 by way of ports 72 incorporated in the contact face 63. With this arrangement, the everting tube wipes over the contact face 63 and so is exposed to resin delivered from the resin chamber 67. The resin from the resin chamber 67 also flows into the space 68 bounded by the pressure plate 65 and the everting tube 17 to ensure that the everting tube is fully exposed to the resin and travels back down the tube to fill and wet the tube as it approaches the pressure plate.

A lance 73 projects rearwardly from the pressure plate 65 and terminates at a protrusion 74 which is received in the collapsed interior of the tube 17 between side portions 18, 19 as the tube approaches the installation head 21. The protrusion 74 is of bulbous configuration and incorporates a rounded nose 75 which is presented to the oncoming collapsed tube. The protrusion 74 serves to expand the collapsed tube wall to create a cavity 76 into which resin is delivered by way of delivery ports 77 incorporated in the nose 75 and communicating with a central bore 78 in the lance 73. The central bore 78 receives resin from the

resin supply by way of delivery line 80. The design of the lance 73 is such as to provide a base attached to the pressure plate 65 of small circumference and the protrusion 74 of a larger circumference. In this way the lance 73 follows the general shape formed by the tube as it is everting with the everting face itself being the point of highest pressure and the area just before the everting face being a point of low pressure. Therefore it is easier to form a cavity just behind the everting face. The cavity 76 into which the resin is delivered creates a "wet-out chamber" within the collapsed tube for the purposes of initially presenting resin to the tube. The objective of the embodiment in this preferred arrangement is the creation of a long "wet out" chamber by the hydraulic force of the resin bulging the everting tube. The length and size of the wet out chamber can be controlled by the resin injection pressure and the inflation pressure within the everting tube. The balance to be achieved is the length of the wet out chamber and the wet out rate. The longer the wet out chamber the longer time the resin is exposed to the fibreglass the faster the rate of progress.

In the embodiment, the separation of the resin chamber 67 from the force of the everting tube 17 driving and pressing against the rear of the installation head 21 means that the resin pressure need only be enough to fill the depth of the pipe and that this is consistent and can be monitored. Also the content of resin in the chamber can be monitored in various means to ensure that all air is purged from the resin volume.

The installation head 21 further includes a guide structure 81 about which the tube 17 passes as it everts. The guide structure 81 comprises a guide ring 82 having a ring body 83 with a central opening 84 therein. The ring body 83 presents a guide surface 85 about which the tube 17 turns, with the inner tube portion 31 entering the ring body 83 through the central opening 84 and the everting portion 33 passing around the guide surface 85 such that the outer tube portion 32 leaves from the outer periphery of the ring body.

The guide structure 81 may be configured to avoid, or at least reduce, the tendency for formation of wrinkles and folds in the tube 17 as it everts. In this regard, the guide structure may comprise a guide ring structure of the configuration disclosed in PCT/AU01/00563 (WO 01/88338).

The guide structure 81 serves to present the tube 17, and in particular first layer of fibreglass fabric, to the contact face 63 for exposure to, and impregnation by, the resin.

The guide structure 81 moves with the body 23 as a result of interaction between the protrusion 74 and rollers 93 mounted on a support structure 95 extending rearwardly from the ring structure, with the wall of the tube 17 passes through the gap 97 between the rollers and the protrusion 89. Consequently, a pulling force applied to the body 23 by way of the tow line is transmitted to the guide structure 81 so that it moves in unison with the body 23 by interaction between the protrusion 74 and the rollers 93.

The body 23 incorporates a plurality of holding chambers 100 disposed axially therealong. In this embodiment, there are three such holding chambers 101, 102 and 103.

Each chamber 100 is defined between two spaced apart annular wiper seals 104 and an inner wall 105. The outer periphery of each chamber 100 is exposed directly to the interior surface 13 of the pipeline 15.

Each inner wall 105 is of flexible construction and can be subjected to vibration for the purposes of pressurising contents of the chamber in a pulsating fashion.

In this embodiment, each chamber 100 is adapted to receive resin from the resin supply for the purposes of depositing a layer of resin onto the interior surface 13 of the pipeline 15 prior to application of the liner in position. This further ensures that there is adequate resin for the purpose of wetting out the fibreglass fabric 18.

The chambers 100 operate at different resin pressures; for example, chamber 101 has a higher resin pressure than chamber 102 which inturn has a higher resin pressure than chamber 103. The progressively decreasing resin pressure extending from chamber 101 down to chamber 103. The progressive reduction in resin pressure reduces the likelihood of resin leakage from the installation head 21. Any leakage from chamber 101 (which is at the highest resin pressure) can either be rearwardly towards the everting tube 17 (where resin is required in any event) or forwardly into chamber 102 (which is at reduced pressure relatively to chamber 101). Similarly, any leakage from chamber 102 can either be rearwardly to chamber 101 (which is unlikely owing to the higher pressure in chamber 101) or forwardly to chamber 103 which is at reduced pressure compared to chamber 102. Because chamber 102 is at a reduced pressure, there is little likelihood of leakage from that chamber. If, however, there is leakage from chamber 102 it is unlikely to be of any consequence as it would simply be leakage which deposits resin onto the interior surface 13 of the pipeline 15 where it is required in any event.

The annular seals 104 each comprise a seal face 107 pivotally connected at hinge 109 to the body 23. The seal face 107 is of annular configuration, as is the hinge 109. The hinge 109 is typically is a film hinge.

The seal face 107 is incorporated in an annular seal body 111 which also incorporates an annular inflation chamber 113. The seal face 107 comprises bristles which are forced outwardly for sliding and sealing engagement with the interior surface 13 of the pipeline 15 upon inflation of chamber 113 as the installation head 21 moves along the pipeline. Because the seal face 107 is biased outwardly, it can follow irregularities in the interior surface 13 of the pipeline. When the inflation chambers 113 are deflated, the seals 104 can collapse inwardly so moving the seal faces 107 away from the interior surface 13 of the pipeline. This is particularly advantageous during initial insertion of the installation head 21 into, and removal of the installation head from, the pipeline 15. Because the seals 104 are retracted, they do not engage the interior surface 13 of the pipeline 15 for ease of travel along the pipe when not in operation and

during insertion and removal of the installation head 21, so allowing the process to be performed without interference which otherwise might occur through engagement of the seals 104 with the interior surface 13 of the pipeline 15. Once the installation head 21 is in position in the pipeline 15, the various chambers 113 can be inflated so as to move the seal faces 107 into sealing engagement with the interior surface 13 of the pipeline 15.

The installation head 21 may further comprise a series of axially spaced brush devices 115 positioned behind the leading end 27 of the body 23. Each brush device 115 comprises an annular base 116 with bristles 117 projecting therefrom for brushing engagement with the interior surface 13 of the pipeline 15. The brush devices 115 are linked one to another by way of flexible cables 118. The brush devices 115 are intended to remove debris from the interior surface 13 of the pipeline 15 in order to prepare the surface to receive resin for bonding the liner 11 in position.

A series of chambers 123 are defined between the brush devices 115. The chambers 123 are adapted to contain air at differential pressure such that the air in the trailing chamber is at the highest pressure and the leading chamber at the lowest pressure, with the pressure in the intervening chamber being at an intermediate level such that there is a progressive increase in air pressure from the trailing chamber to the leading chamber. Using this means a flow of air can be generated forwardly from one chamber to the next in the event a fault in the pipeline 15 allows air to leak from one chamber to the next. In the process of moving from one chamber to the next, the air flow will dislodge debris such as sand and gravel particles and displace water resting in any cavities of the pipeline 15 by either blowing it out in front of the installation head 21 for collection or, if there is a hole in the pipeline 15, by displacing the water and debris through the hole to the outside of the pipeline.

Also in this way the lining tool can operate in a pipe that is under the water table by displacing the water by air pressure.

The installation head 21 may further include a collection means 119 for collecting debris within the pipeline 15 prior to installation of the liner 11. The collection means 119 comprises a suction system having a suction head 120 connected to a suction line 122.

The apparatus 10 can be equipped with various sensing and monitoring devices to facilitate regulation of the installation process for the liner 11 with the objective of establishing and maintaining optimum conditions therefor. Such sensing and monitoring devices may include means for conducting visual inspections of the pipeline 15 prior to, during, and/or after the installation process. Additionally, such devices may permit a determination to be made as to the extent (if any) of cleaning required for the pipeline surface.

Further, such devices may enable calculation of the optimum volumetric quantities and delivery rates for the resin. In this way, delivery of the resin can be controlled to allow application of appropriate quantities. Thus, the delivery rates (and hence volume i) of resin can be regulated on an ongoing basis during the installation process where for example it may be necessary to apply more resin at some locations than at other locations because of variations in the pipeline condition along its length. As well as avoiding wastage of resin, this may also allow the installation speed to be increased at locations where reduced resin quantities are required.

Still further, the sensing and monitoring devices may allow optimum curing conditions for the resin to be determined, having regard to factors such as, for example, temperature and humidity. This may permit the composition of the resin to be varied as necessary in an endeavour to provide optimum curing conditions, by for example adding, removing or varying the quantity of components such as accelerators, activators and/or catalysts.

Other sensing and monitoring devices may include sensors for measuring the strain and load on the everting liner.

The use of the sensing and monitoring devices facilitates ongoing, or at least regular, feedback for maintenance of optimum installation conditions. This enhances the reliability of the installation process.

Operation of the apparatus 10 installing the liner 11 in the pipeline 15 will now be described.

The installation head 21 is positioned within the pipeline 15 adjacent the end thereof at which the lining operation is to commence. The leading end 27 of the body 23 is connected to a tow line which extends to the other end of the pipeline and terminates at a station at which various operations are performed including retraction of the tow line in order to pull the installation head 21 along the pipeline. The installation duct 34 is positioned adjacent the commencement end of the pipeline 15 and the delivery structure 37 is installed at a convenient location, typically at ground level in the vicinity of the end of the pipeline. The delivery duct 35 is then positioned between the installation duct 34 and the delivery structure 37. Because of its flexible nature, the delivery duct 35 can conveniently follow an access path dug in the ground leading to the end of the pipeline. The tube 17 is then passed in a collapsed condition through the entry end 45 of the delivery chamber 39 within the delivery structure 37 and along the delivery duct 35 to project beyond the installation duct 34. The leading end of the collapsed tube 17 is then connected to the installation duct 34 by way of a clamping collar which extends around the tube and sealingly connects it to the end of the duct 34. Fluid pressure is then introduced into the delivery chamber 39 and the delivery duct 35, so as to inflate the delivery duct 35 and commence eversion of the tube 17. As the tube 17 commences to evert, its everting portion is presented to, and guided into the end of the pipeline 15 so that the tube advances along the pipeline as it everts.

As the everting tube advances along the pipeline, it embraces the lance 73, and the everting portion 33 engages the pressure plate 65 at the trailing end of the body 23. The rate of advancement of the everting tube 17 along the pipeline 15 is controlled by the rate at which the installation head 21 itself travels, with the

everting face 33 of the tube 17 being in wiping contact with the contact face 63. Because the contact pressure exerted by the everting tube 17 is directed onto the pressure plate 65, the resin itself is not pressurised and can flow freely through the apertures 71 and into the space bounded by the pressure plate 65 and the everting portion 33 of the tube 17. Resin within the resin chamber 67 passes through the apertures 71 in the pressure plate 65 and so contacts the everting portion of the tube 17 to impregnate the fibreglass layer thereof. The fibreglass layer is also wetted with resin through exposure to resin at the nose 75 of the lance 73. As the installation head 21 advances along the pipeline 15, resin is applied to the interior surface 13 of the pipeline by way of the chambers 100.

Because of the various locations at which resin is presented to the fibreglass layer of the tube 17 by the time it contacts the interior surface 13 of the pipeline 15, optimum resin impregnation of the fibreglass fabric is achieved.

Inflation pressure within the everting tube 17 presses the outer portion 32 of the tube 17 into intimate contact with the interior surface 13 of the pipeline 17. The process continues until the installation head 21 reaches the other end of the pipeline 15, where it can be withdrawn from the pipeline and the surplus end section of the tube 17 clamped to the pipeline 15 so as to close the end of the inflation chamber 41 and thereby maintain inflation pressure within the everted tube 17 until such time as the resin sets to form a composite structure in co-operation with the fibreglass fabric.

In the first embodiment, there was a mechanical connection between the body 23 and the guide structure 81 by virtue of interaction between the protrusion 74 and rollers 93 for the purposes of moving the guide ring structure 81 along the pipeline 15 in unison with the body 23.

In an alternative arrangement, there is may be an electromagnetic connection between the body 23 and the guide structure 81 for such purpose. The electromagnetic interconnection may be the sole connection therebetween or it may be augment a mechanical connection of any appropriate type such as that described in relation to the first embodiment.

The second embodiment, which is illustrated in Figure 9 of the drawings, uses an electromagnetic connection between the body 23 and the guide structure 81. The electromagnetic connection comprises an electromagnet 121 positioned on the pressure plate 65 on the side thereof opposite the contact face 63. With this arrangement, the electromagnet 121 is accommodated within the resin chamber 67. The electromagnet 121 incorporates apertures 123 which align with corresponding apertures 71 in the pressure plate 65 so as not to interfere with flow of resin from the resin chamber 67 to the contact face 63.

A particular advantage of the electromagnetic connection is that the gap between the contact face 63 and the guide surface 85 of the guide structure 81 can be selectively varied by virtue of the intensity of the magnetic field which is established. In this way, the drag imposed on the tube 13 by the installation head 21 as it advances along the passageway 15 can be regulated. This information can be incorporated into a direct feed back loop so that the process and the thickness of the resin contained between the face and the ring can be controlled .

In this embodiment, the installation head is equipped not only with the electromagnetic connection but also the mechanical connection provided by interaction between the rollers 93 supported on the guide structure 81 and the protrusion 73 provided on the lance 73 projecting rearwardly from the body 23. In this way, the connection between the guide ring 81 and the body 23 is maintained even when the electromagnetic connection ceases.

In the first and second embodiments, the tube 17 everted around a guide structure 81. It should, however, be appreciated that the guide structure may not be necessary in certain applications. The action of fluid pressure within the everting tube 17 may be sufficient to cause eversion of the tube and advance the tube along the pipeline. The rate of advancement of the everting tube along the pipeline is controlled by the rate at which the installation head 21 itself travels, with the everting face 33 of the tube 17 being in wiping contact with the contact face 63. Such an arrangement is illustrated in Figure 10 of the drawings.

The installation head 21 may be equipped with a mechanism 130 for extracting air from cavities which might exist on the upper part of the top part of the interior surface 13 of the pipeline. Such an arrangement is incorporated in the embodiment illustrated in Figures 11 and 12 and includes a suction line 131 having a suction end 133. The suction line 131 adjacent the suction end 133 is configured at 135 to function as a spring arrangement biasing the suction end to an outermost condition projecting beyond the periphery of the body so as to be capable of entering cavities in the top section of the pipeline 15, as illustrated in Figure 12 where it is seen that the suction end 133 has entered cavity 139. Normally, the suction end 133 is retained in a retracted condition as shown in Figure 11, by virtue of contact with the interior surface 13 of the pipeline 15. However, when the suction end 133 encounters a cavity (such as cavity 139 as shown in Figure 12), the suction end 133 can project outwardly and enter the cavity.

The suction end 33 is slightly offset from normal to the surface 13 of the pipeline, with the orientation being away from the direction of movement of the installation head, so as to avoid jarring or catching on the pipeline surface 13.

In the embodiment described, each chamber 123 was adapted to contain air. In an alternative embodiment, the trailing chamber 123 may be adapted to receive and contain nitrogen (or another appropriate gas or gaseous mixture) to displace air and thus provide an inert environment to which the resin is exposed as it is subsequently applied.

From the foregoing, it is evident that the present embodiments provide a simple yet highly effective arrangement for ensuring that the everting tube is properly "wet-out" during installation of the liner 11.

Improvements and modification may be incorporated without departing from the scope of the invention.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Dated this Second day of September 2002.

Shieldliner Co Limited
Applicant

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicant(s)

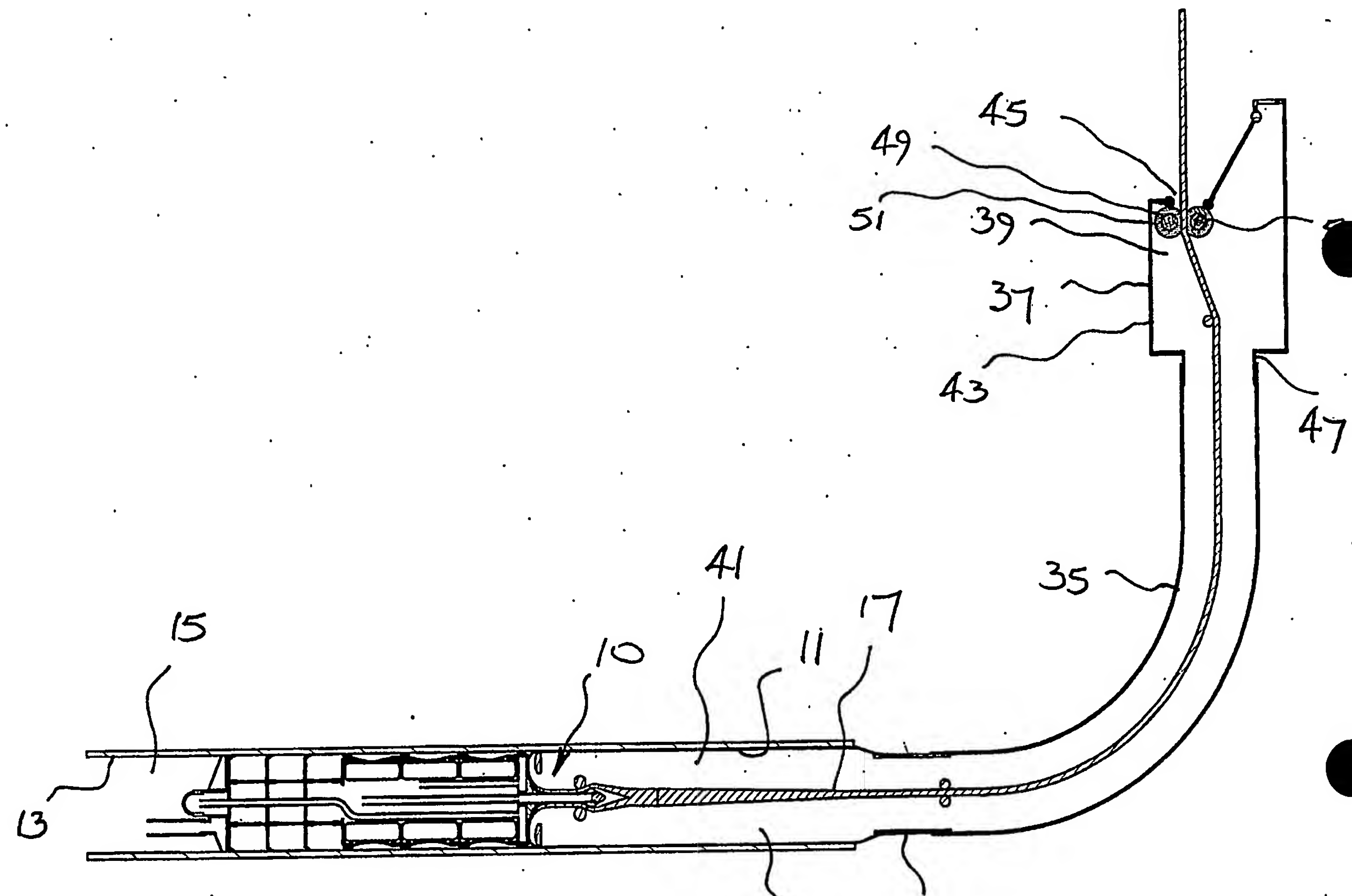

FIG. 1

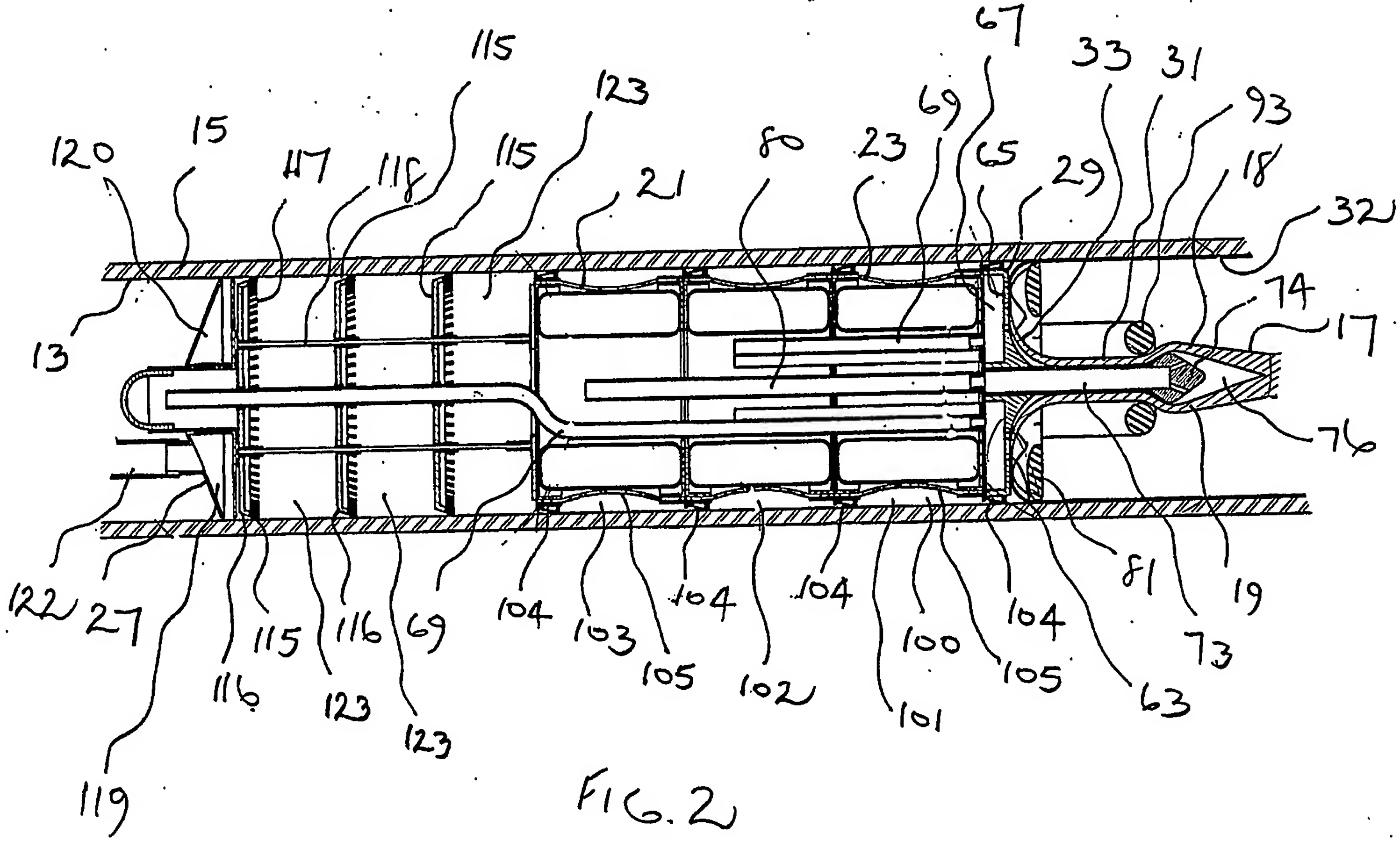

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FIG. 2

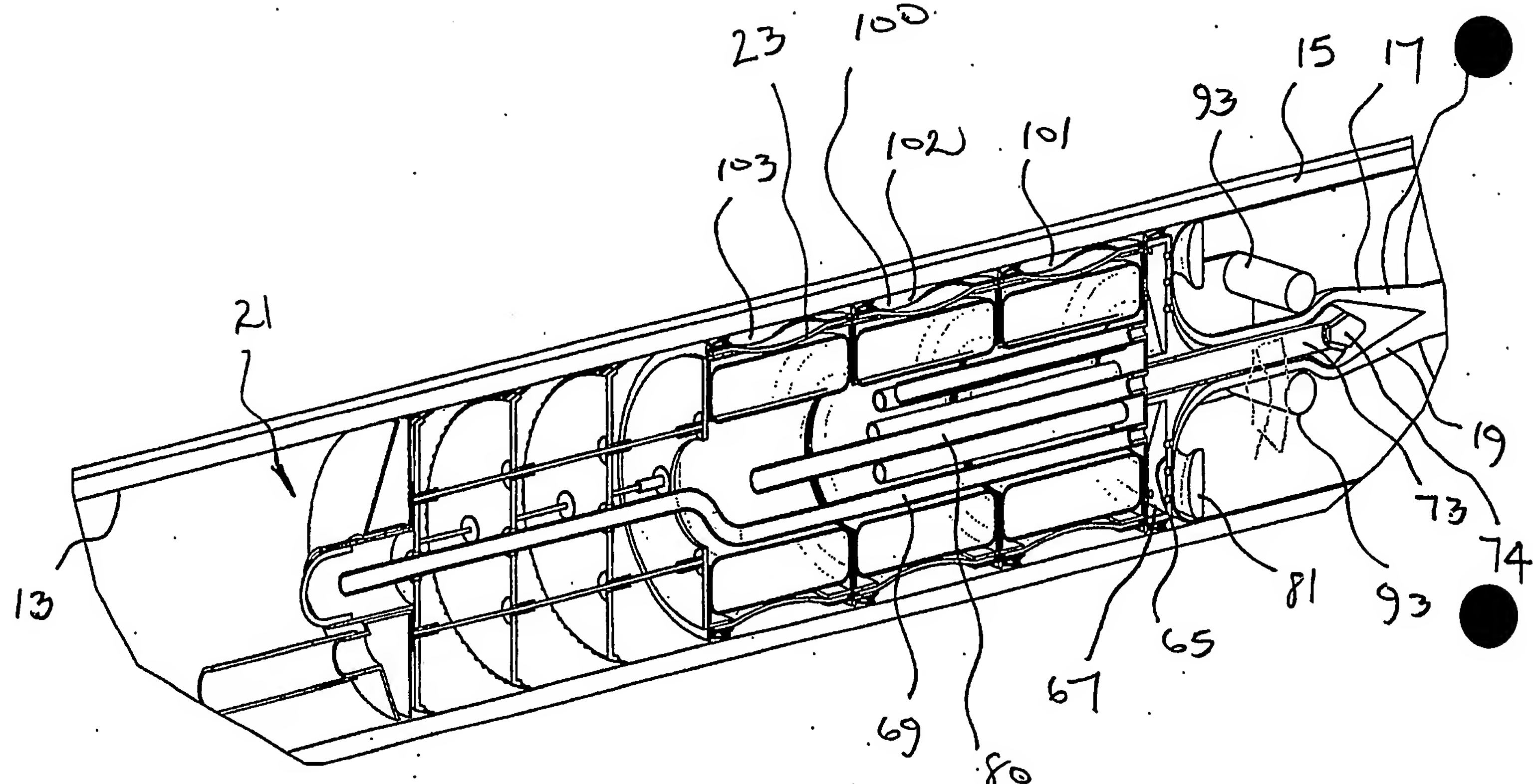

FIG. 3

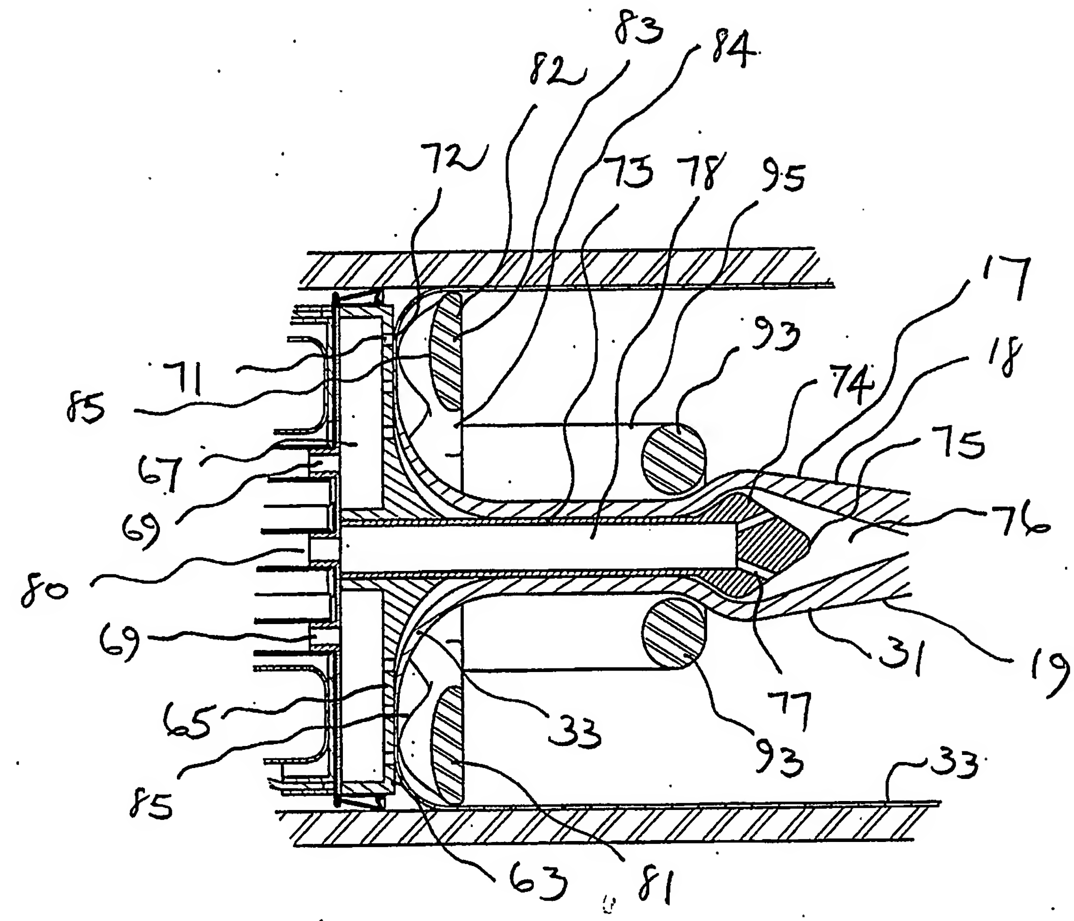

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FIG. 4

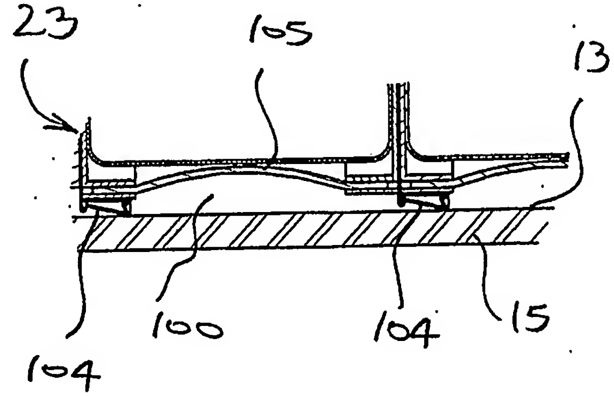

FIG. 5

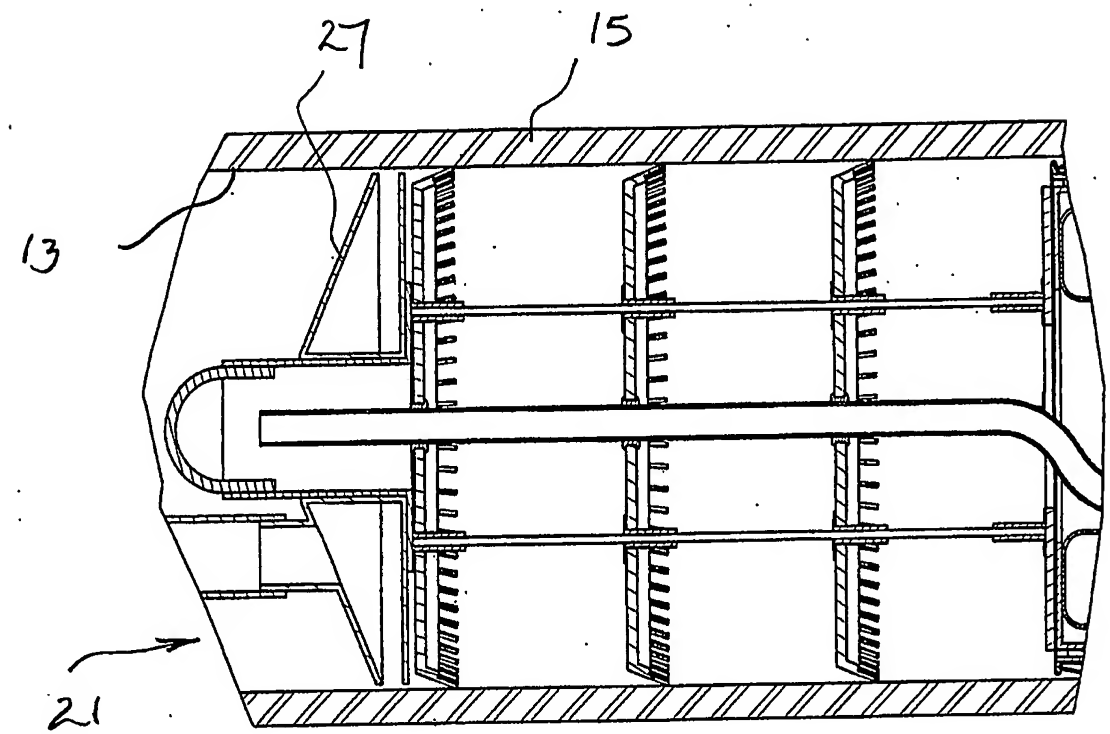

FIG. 6

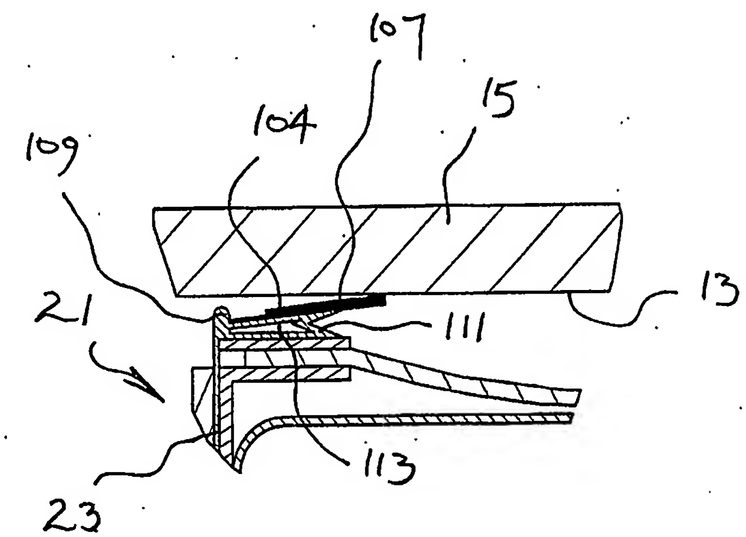

FIG. 7

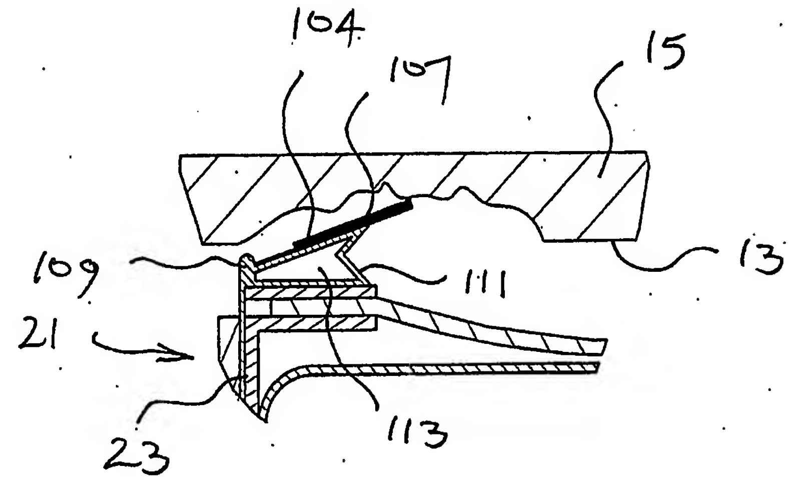

FIG. 8

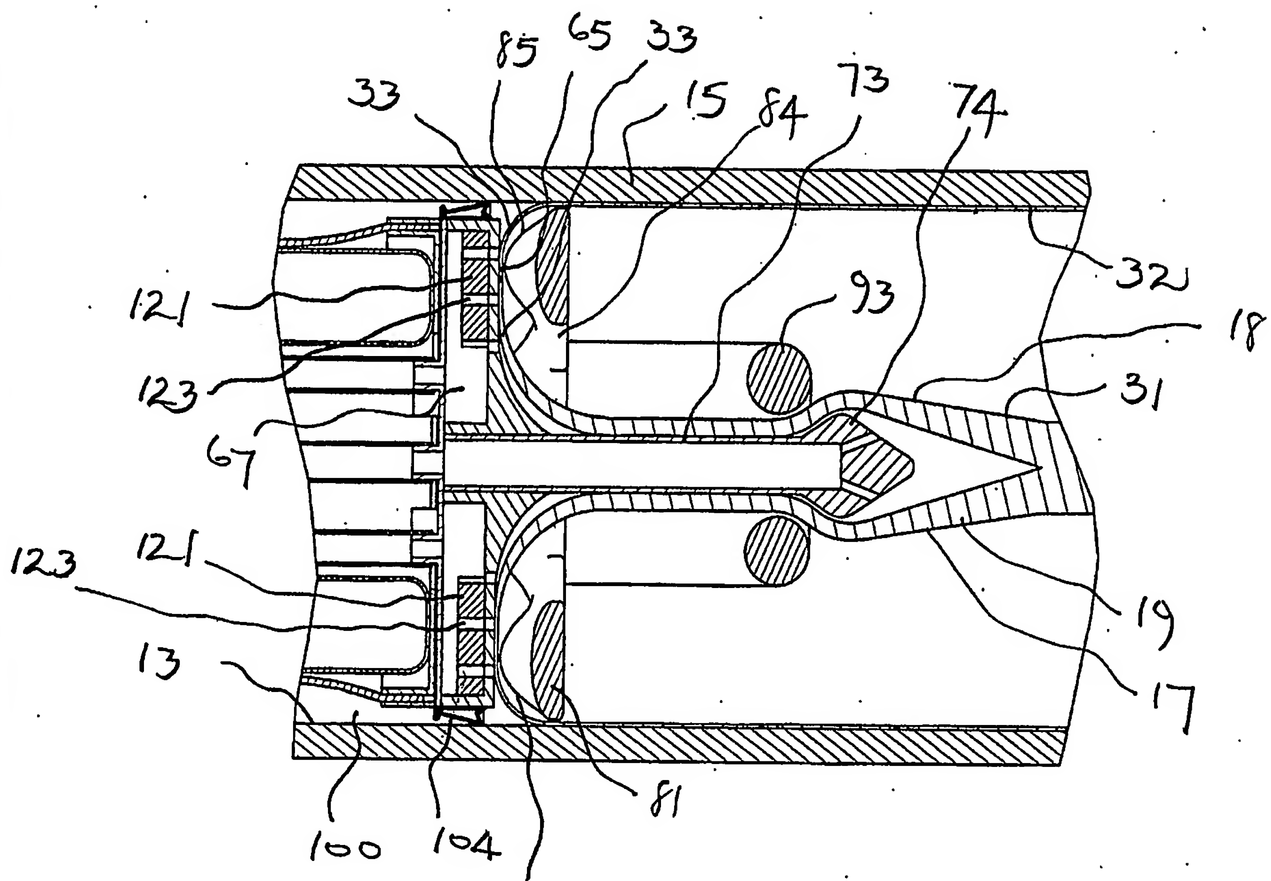

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FIG 9

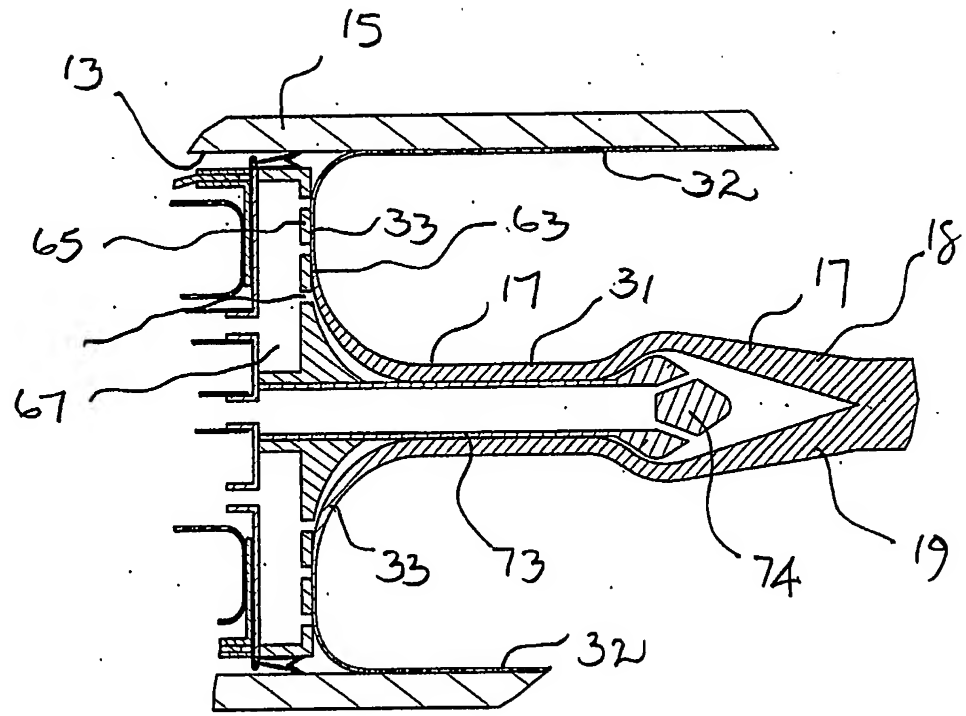

FIG. 10

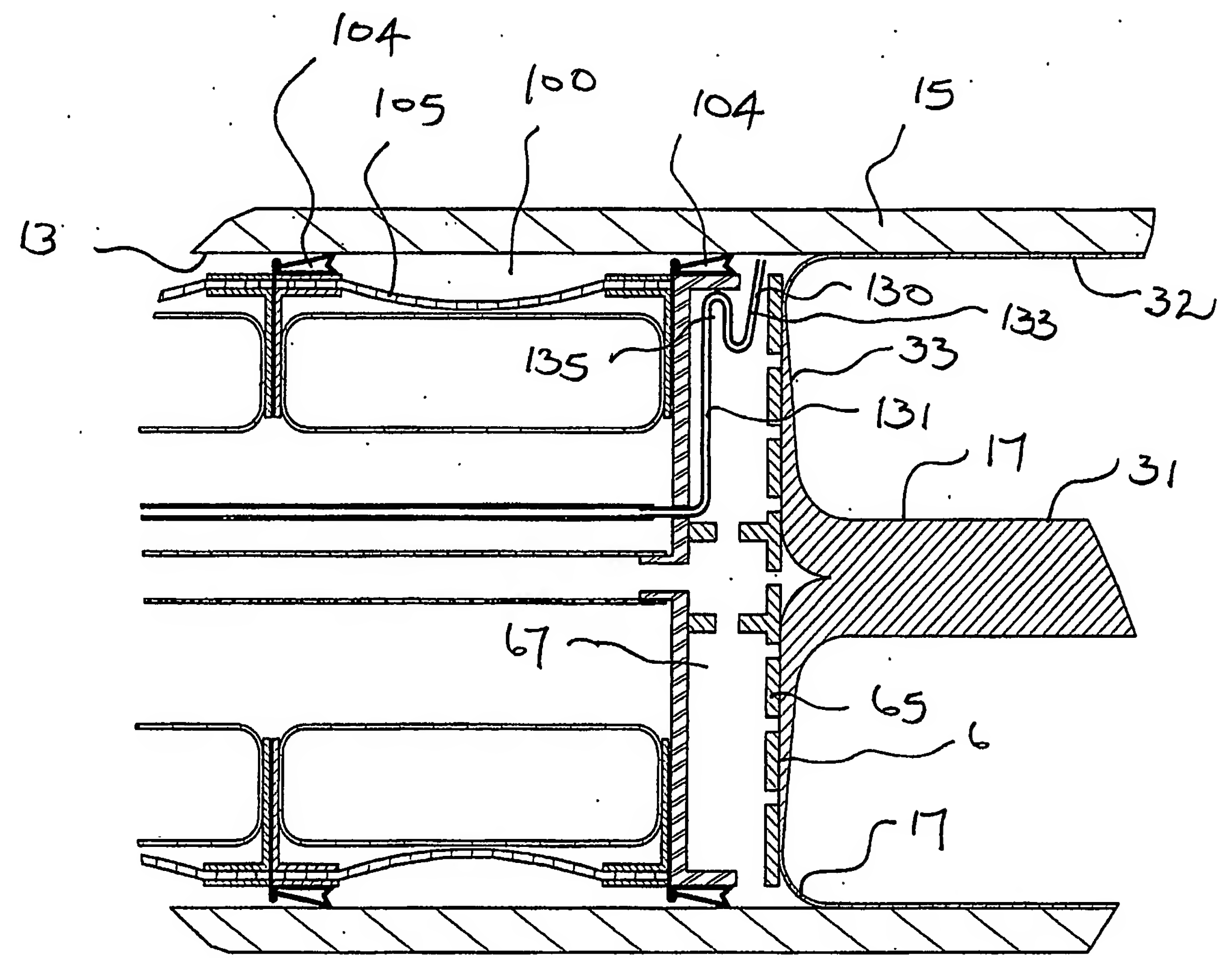

FIG. 11

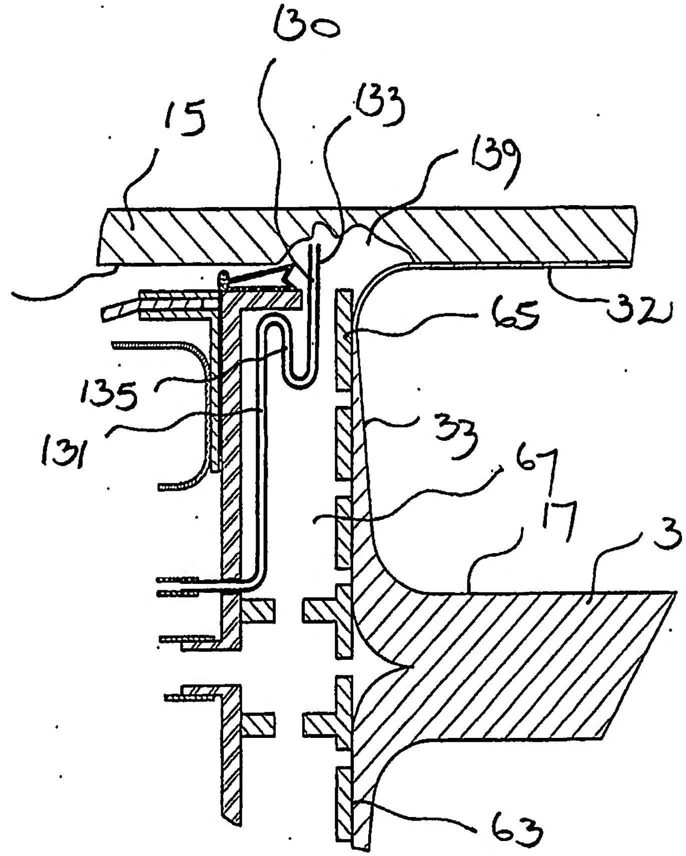

FIG. 12

WRAY
& ASSOCIATES
Progression through Protection

Our ref: 106696 :JHK:jt
Your ref:

2 September 2002

IP Australia
Documents received on:
02 SEP 2002
Perth
Batch No: 00229152

IP Australia
PO Box 200
Woden
Australia

Dear Sir

Provisional Patent Application
ShieldLiner Co Limited
"Apparatus for and Method of Lining Conduits"

We submit herewith the following documents for filing a provisional patent application for the above identified invention:

Patent Request
Specification

The specified fees of AU$80 are enclosed as per the attached lodgement schedule.

Yours faithfully
WRAY & ASSOCIATES

J H King

FEE: $80.00

ALL CORRESPONDENCE
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Perth 6831
Western Australia
E: wray@wray.com.au
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OTHER CONTACT
DETAILS OVERLEAF

106696 Wray & Associates
PATENT & TRADE MARKS ATTORNEYS • Est 1920

P/00/003 28/5/91
Section 29

AUSTRALIA

Patents Act 1990

PATENT REQUEST: PROVISIONAL APPLICATION

We, being the persons identified below as the Applicant, request the grant of a patent for an invention described in the accompanying provisional specification.

Full application details follow.

[71]	Applicant:	ShieldLiner Co Limited 152 Vulcan Road, Western Australia Australia, 6155
[54]	Invention Title:	Apparatus for and Method of Lining Conduits
[72]	Name of actual inventor:	To Be Advised
[74]	Address for service in Australia:	Wray & Associates 6th Floor 239 Adelaide Terrace East Perth Australia

Attorney code: WR

Date: 2 September 2002

a patent attorney of the firm
Wray & Associates,
patent attorneys for and on behalf of the applicant(s).

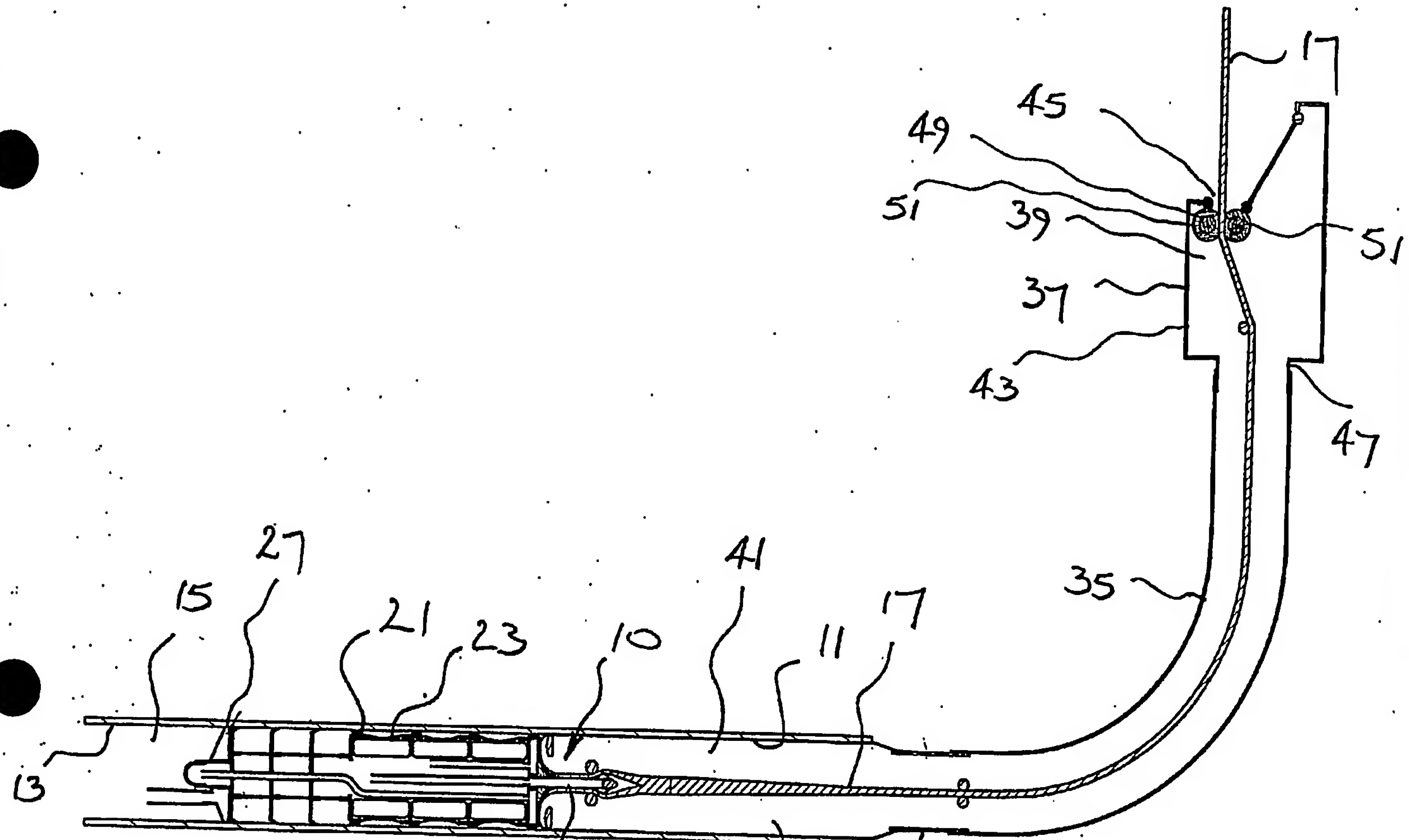

FIG. 1

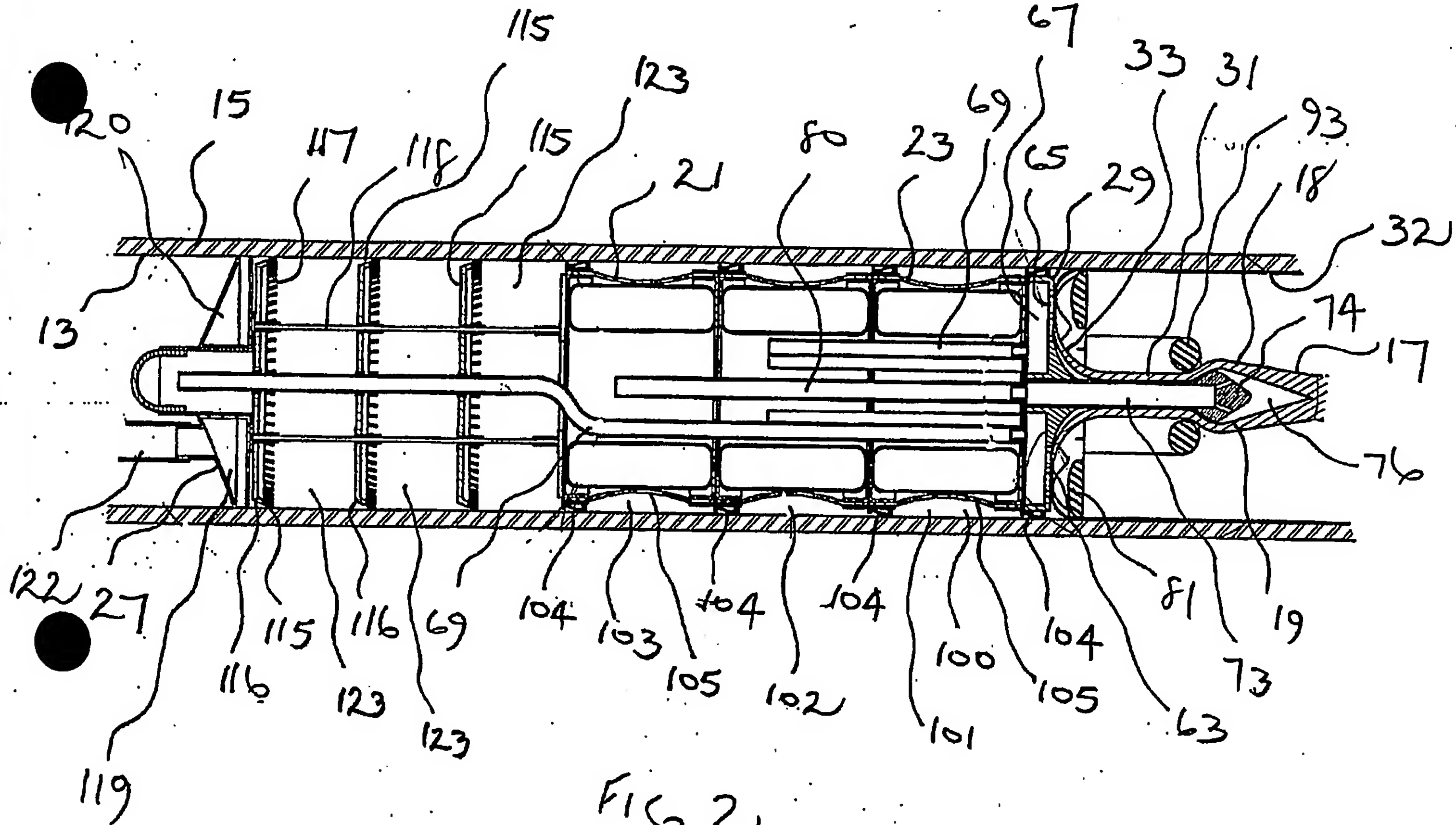

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FIG. 2

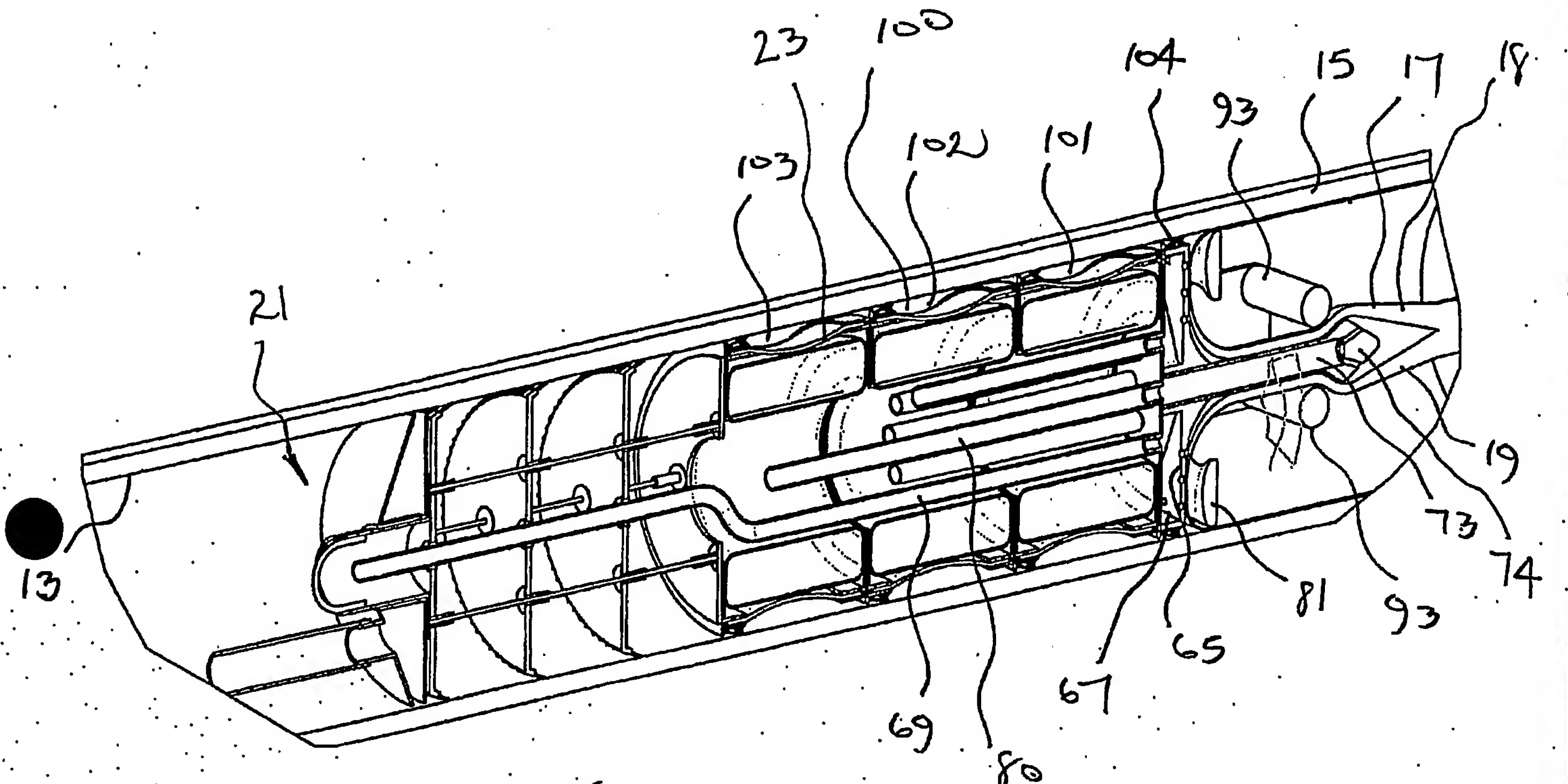

FIG. 3

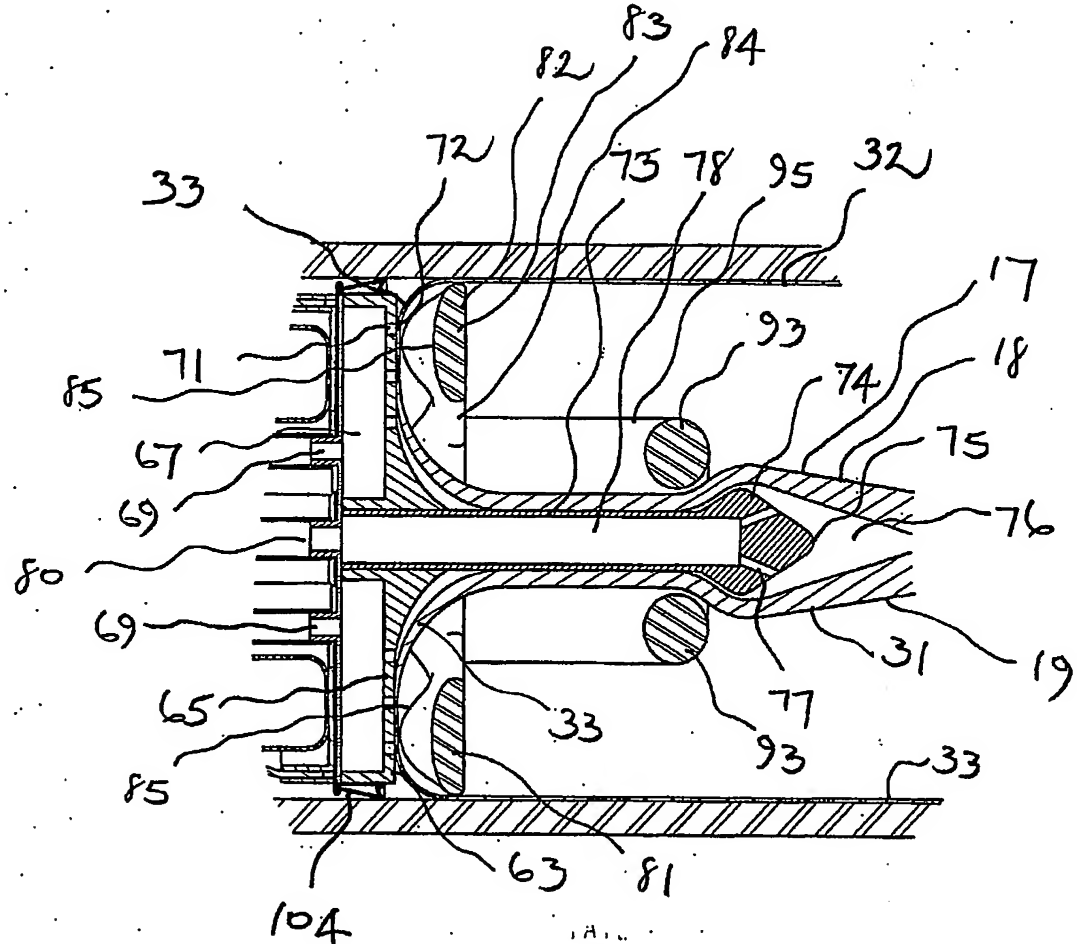
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FIG. 4

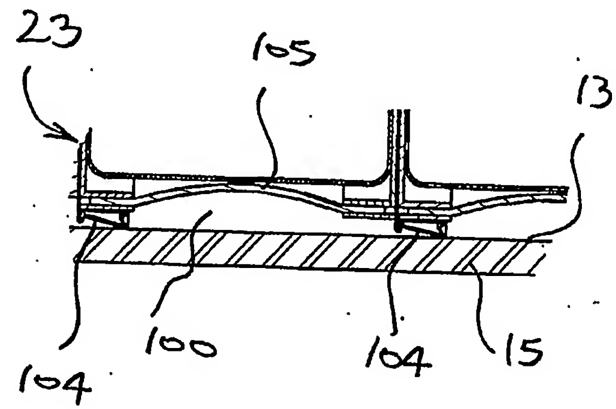

FIG. 5

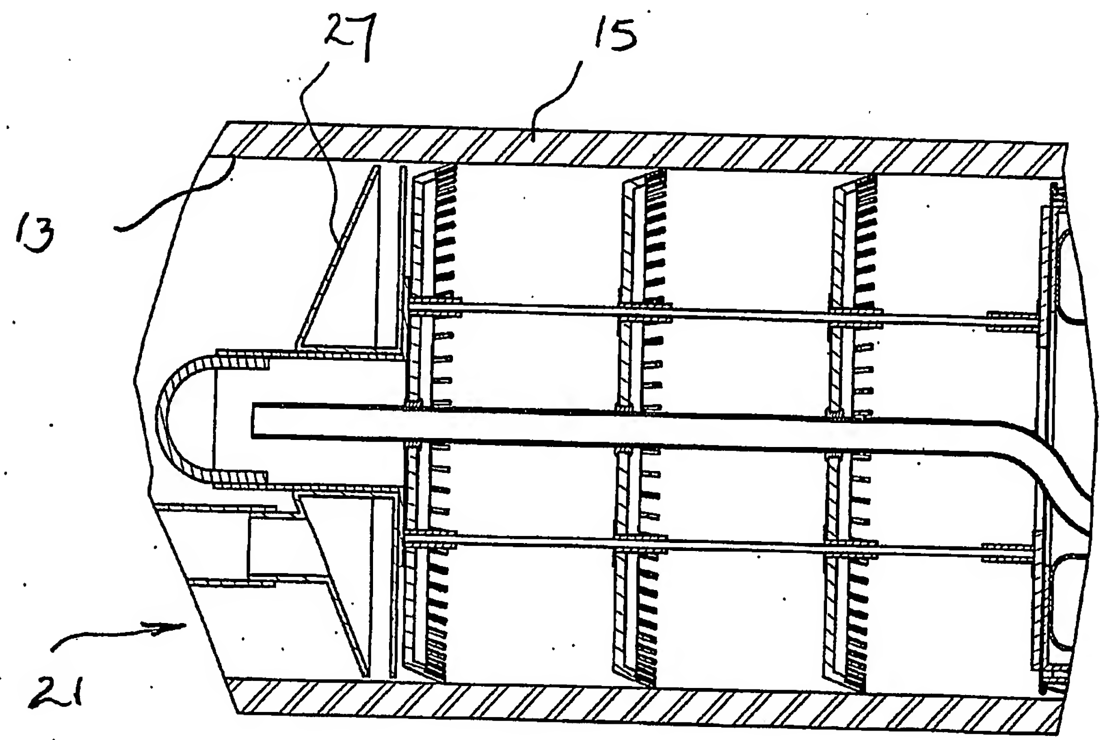

FIG. 6

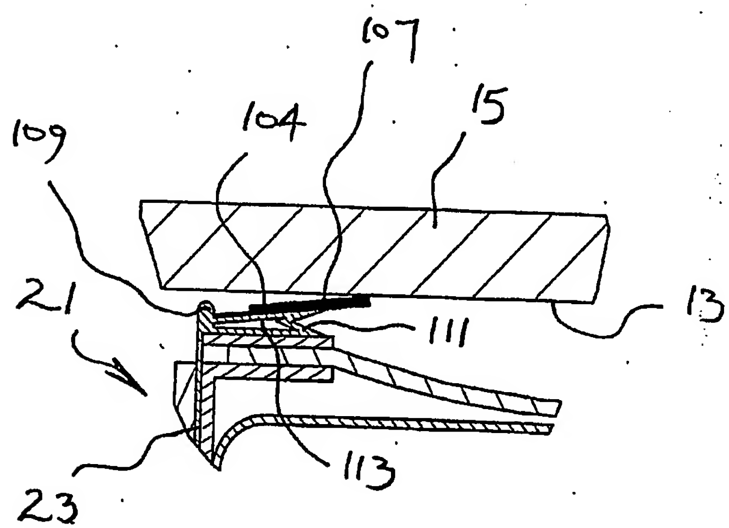

FIG. 7

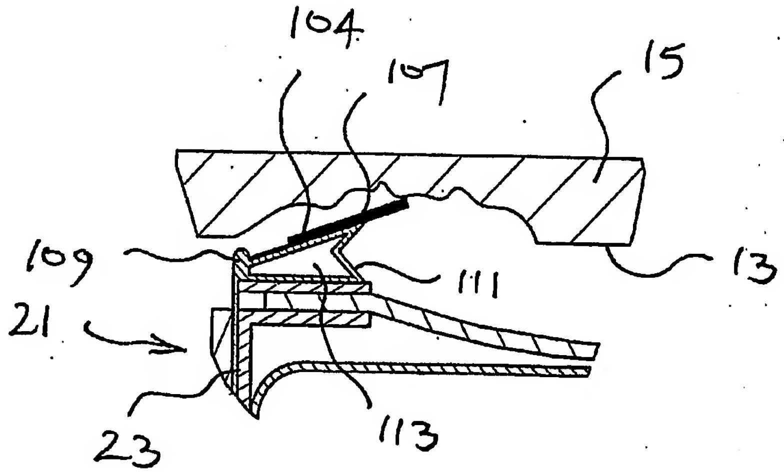

FIG. 8

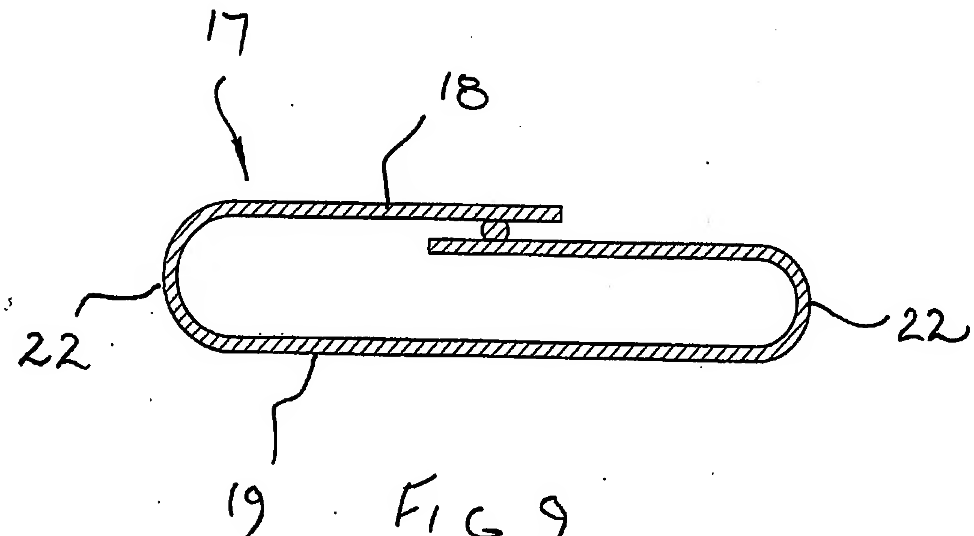

FIG. 9

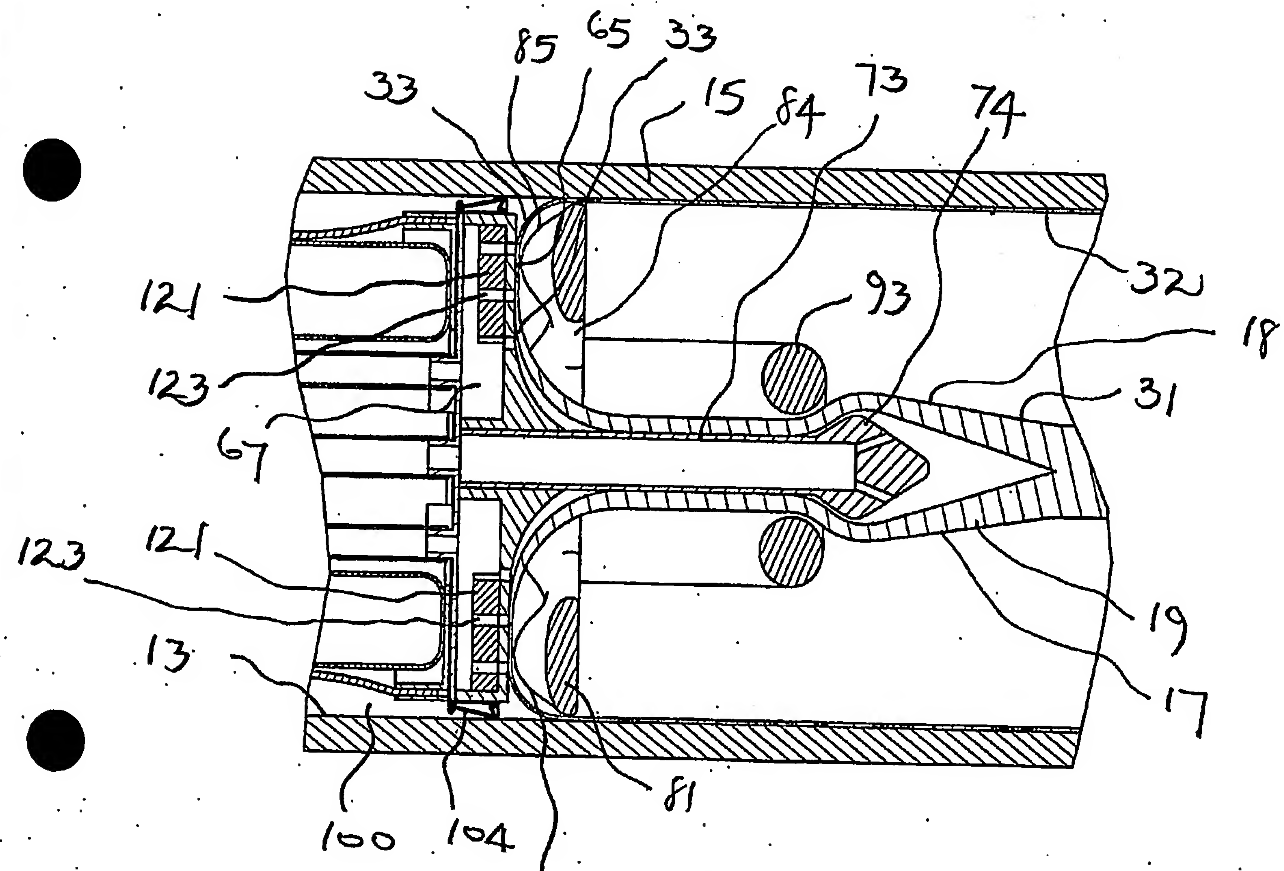
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FIG 10

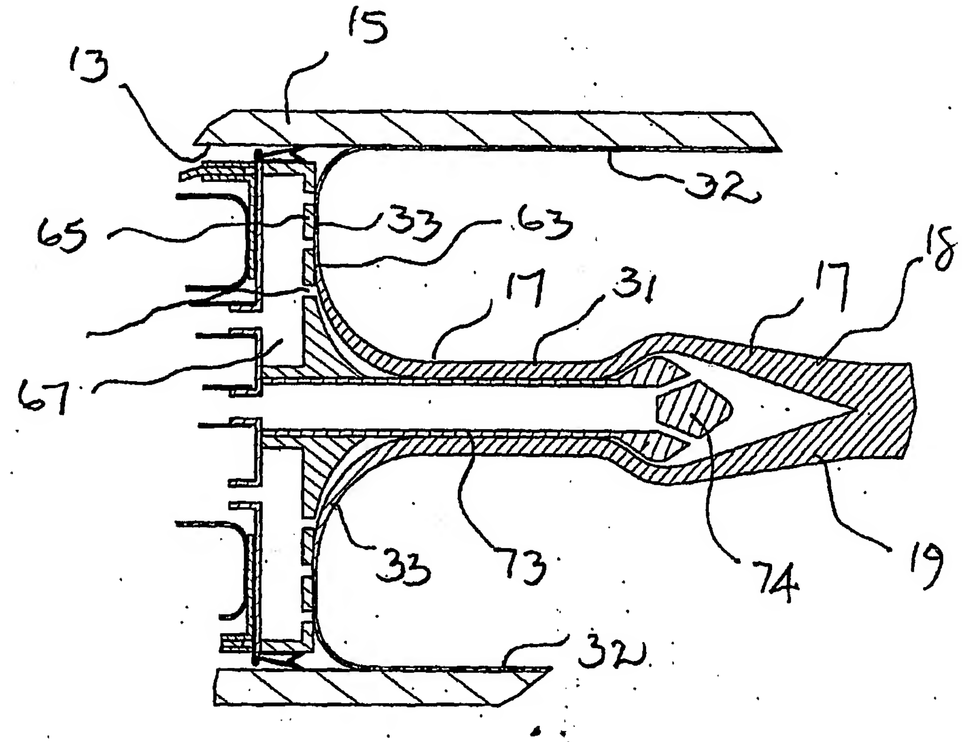


FIG. 11

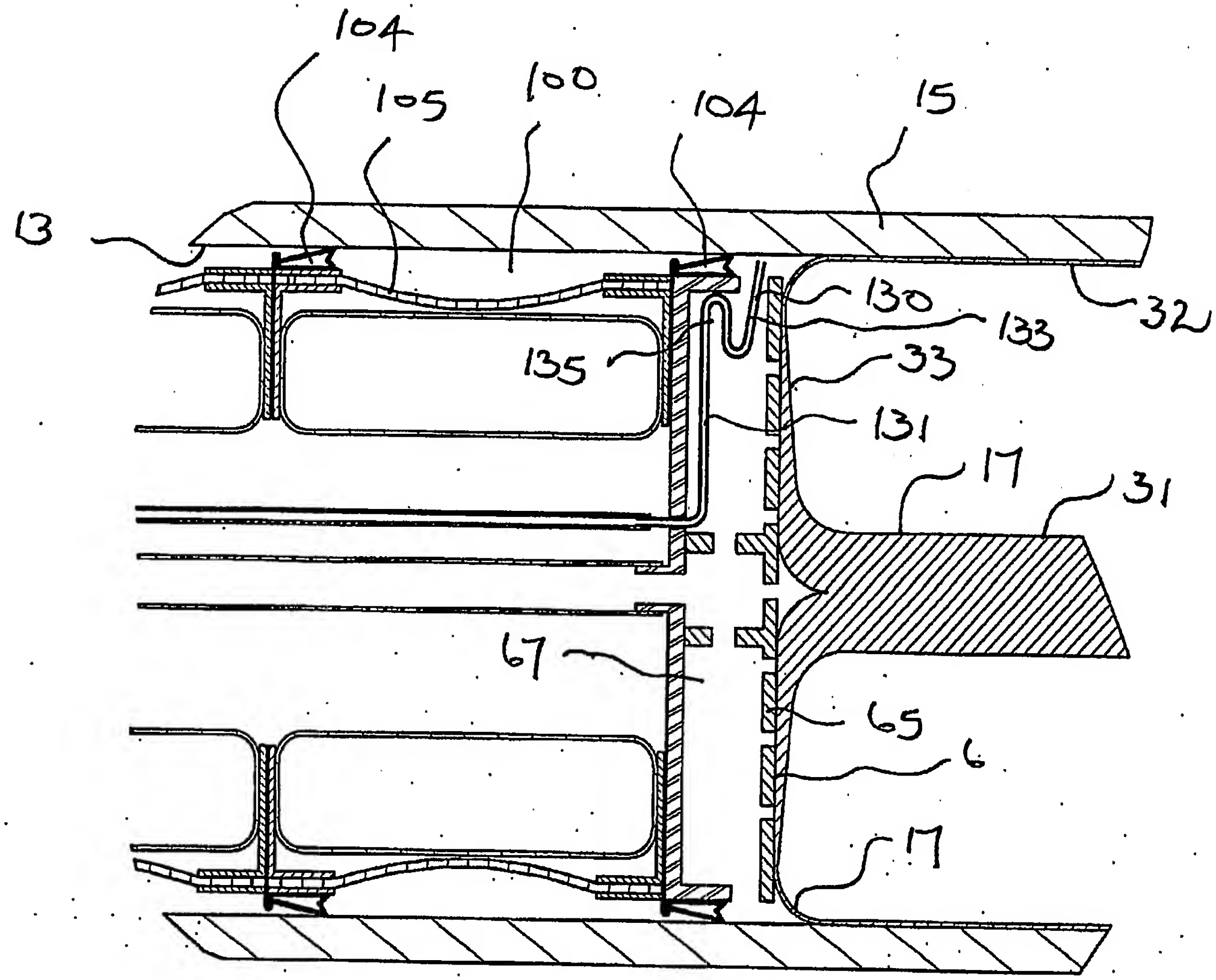


FIG. 12

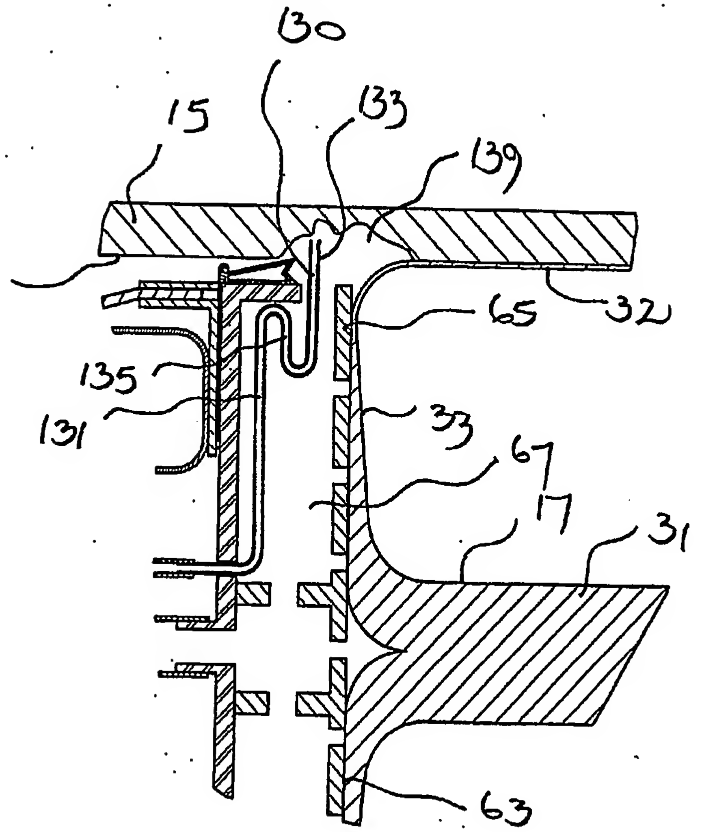


FIG. 13

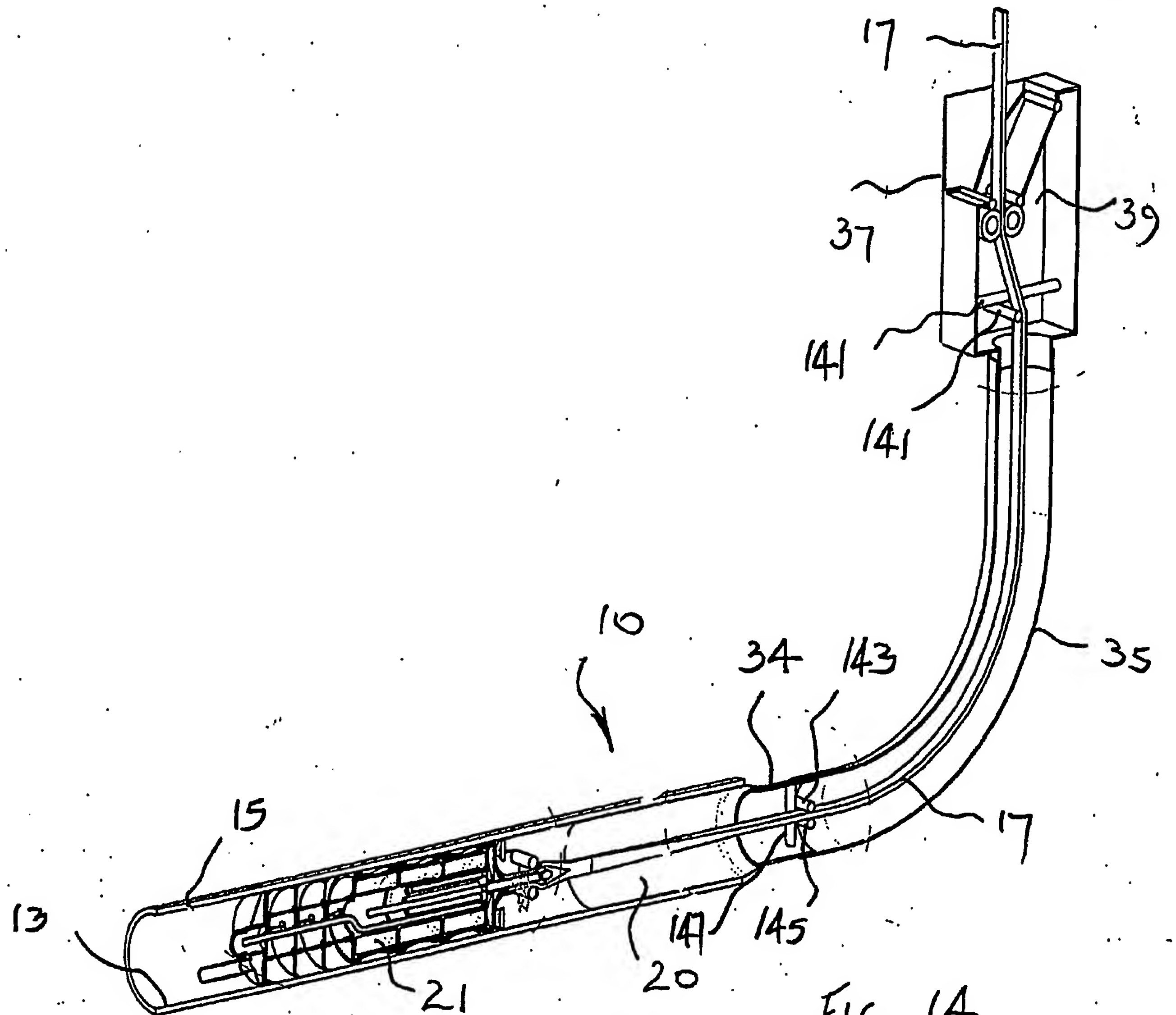


FIG. 14

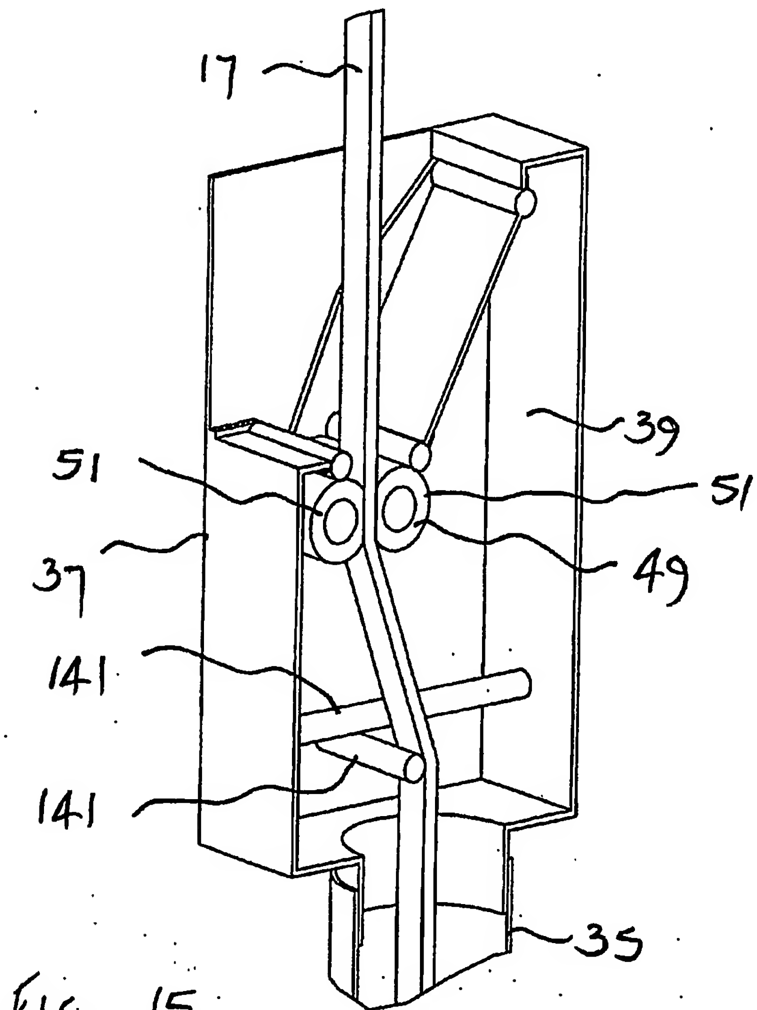


FIG. 15

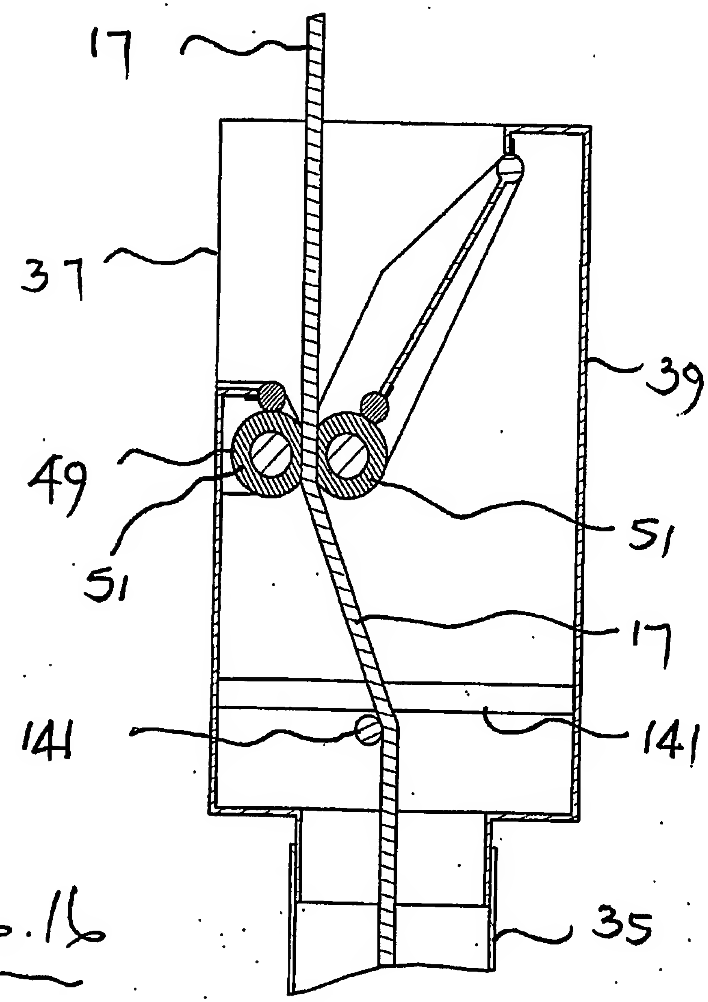


FIG. 16

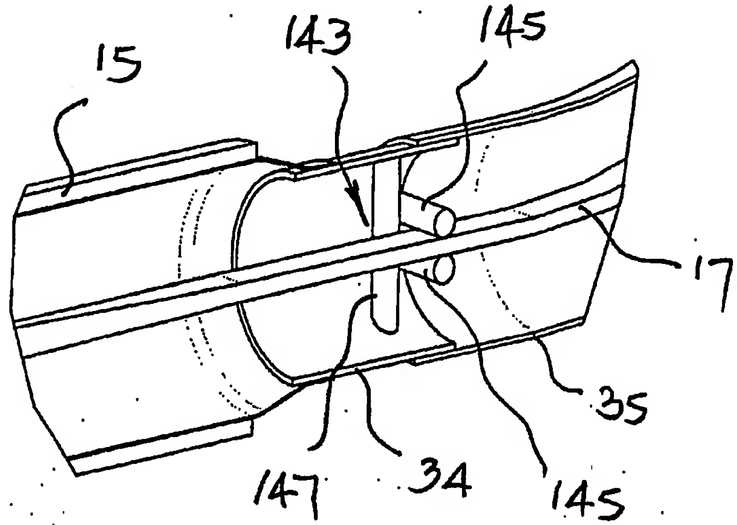


FIG. 17

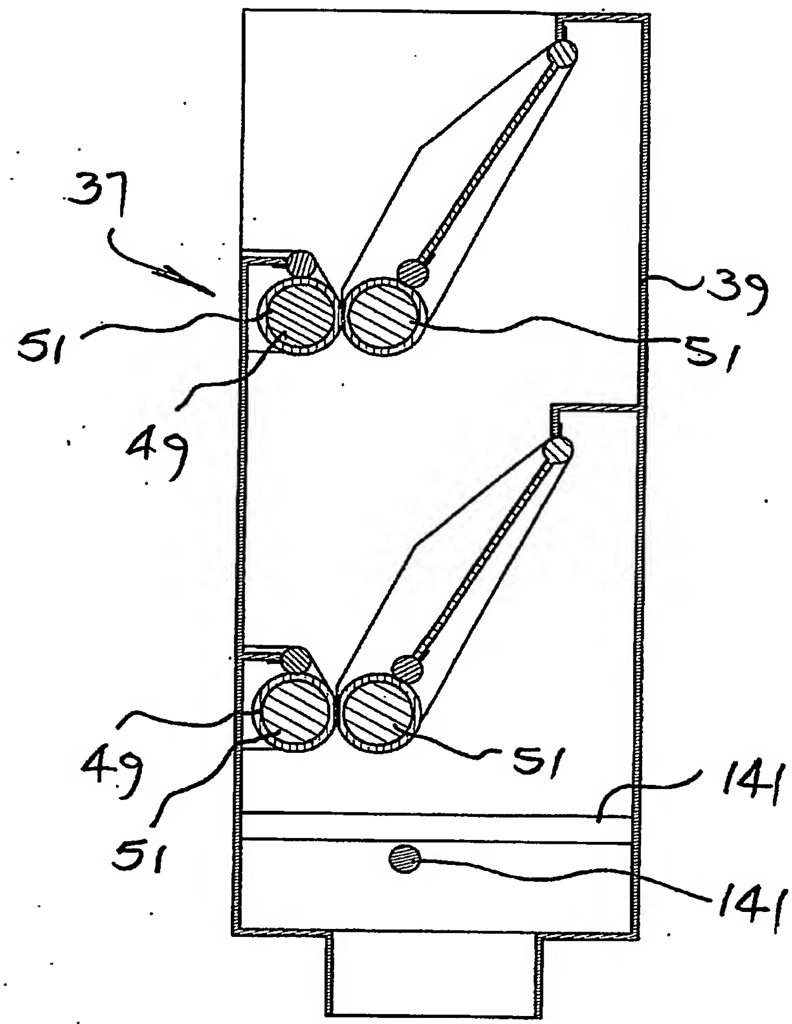


FIG. 18

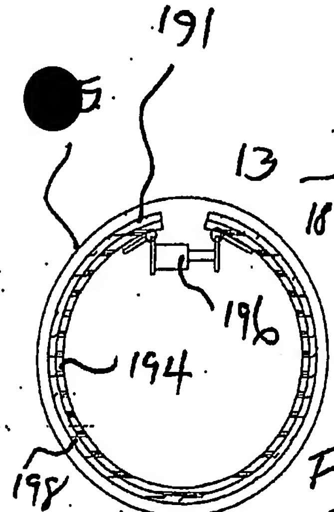


FIG. 20

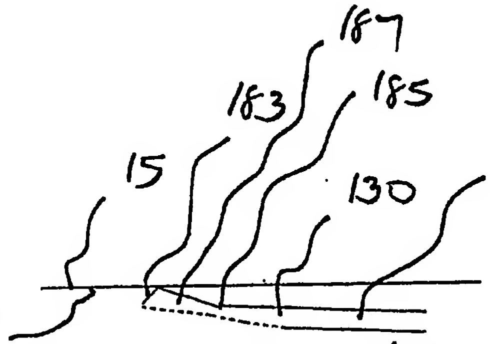


FIG. 21

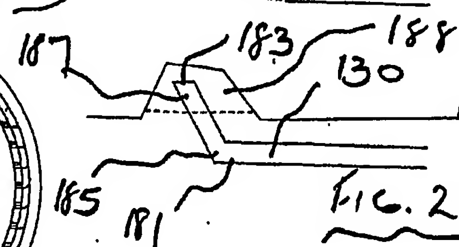


FIG. 22

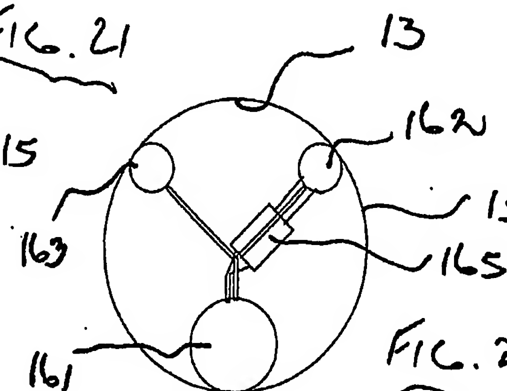


FIG. 23

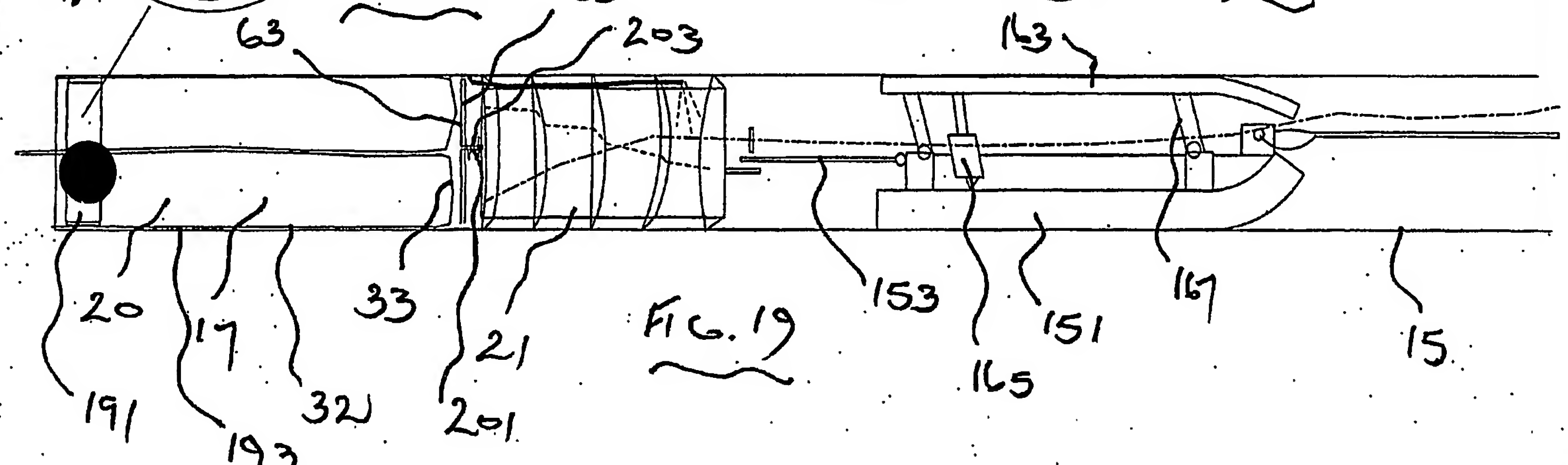


FIG. 19

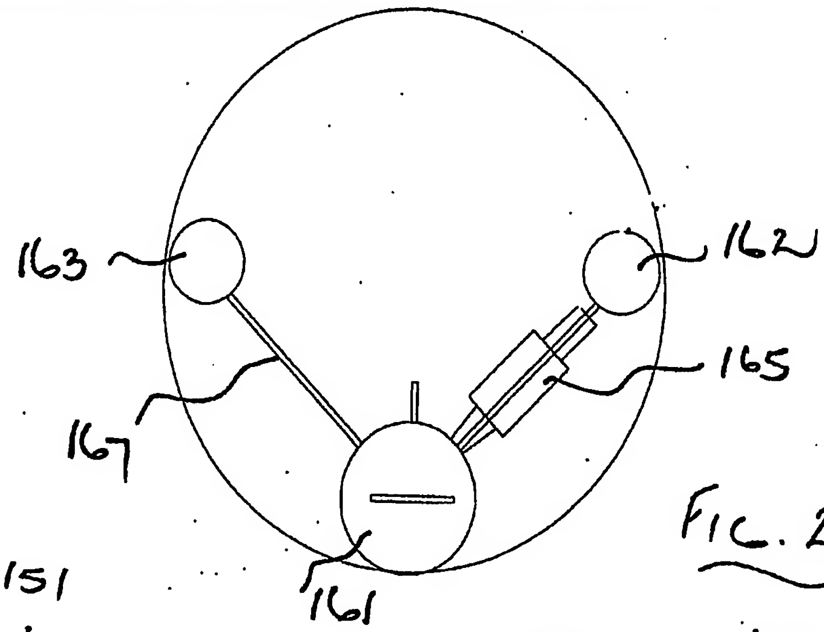


FIG. 24

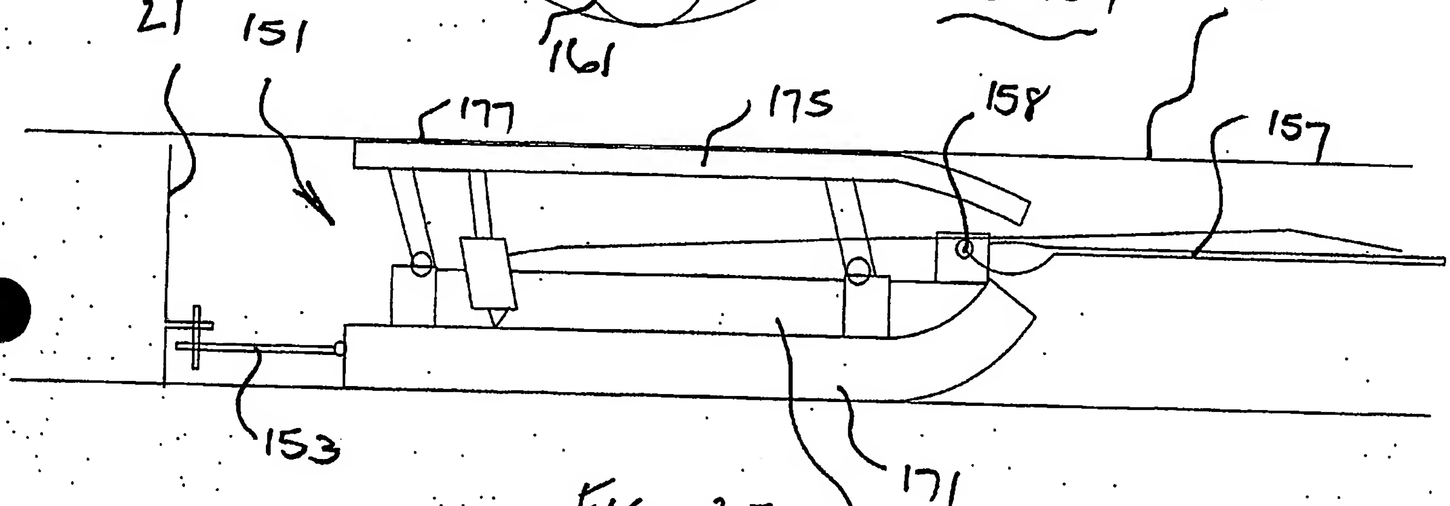


FIG. 25

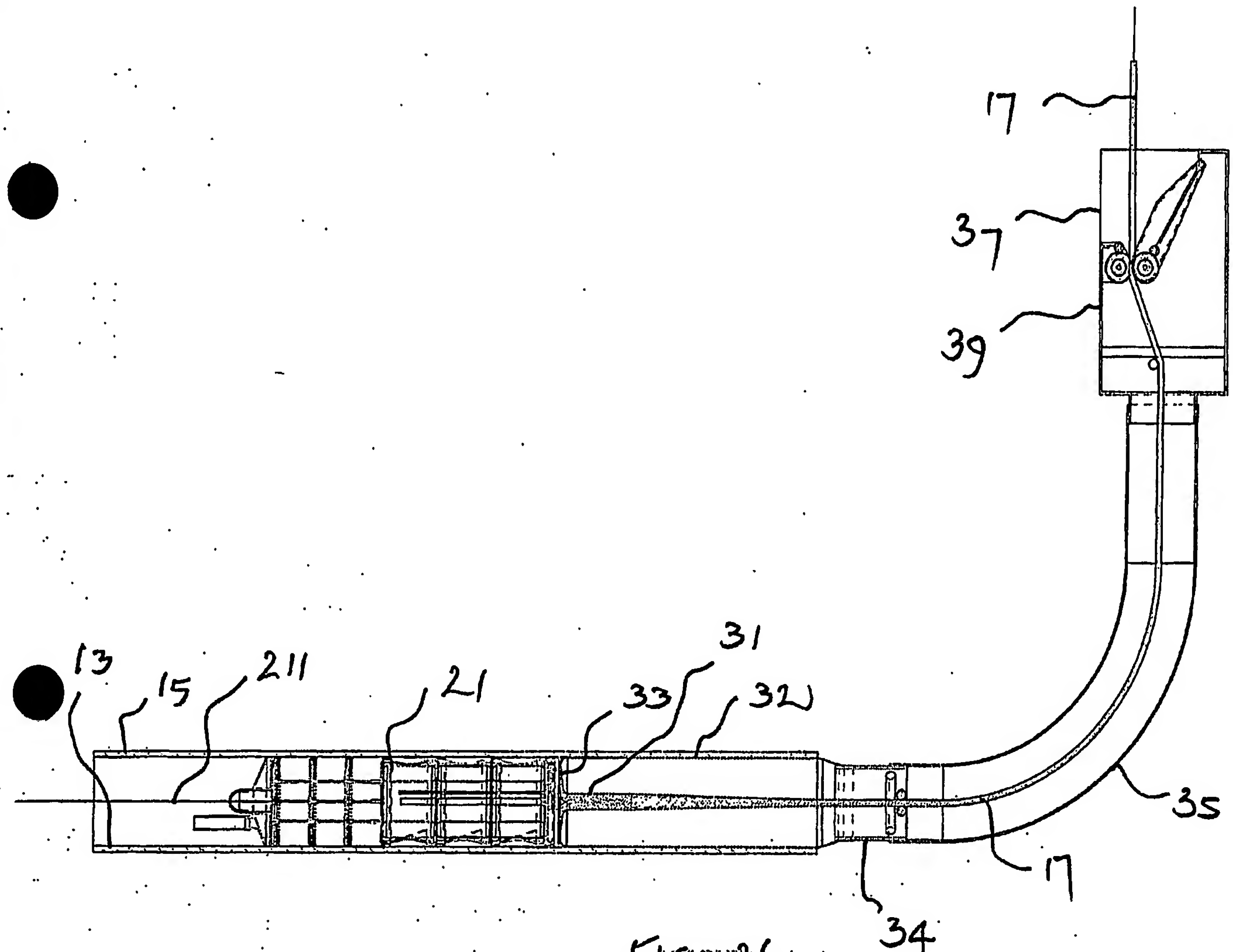


FIG 2C

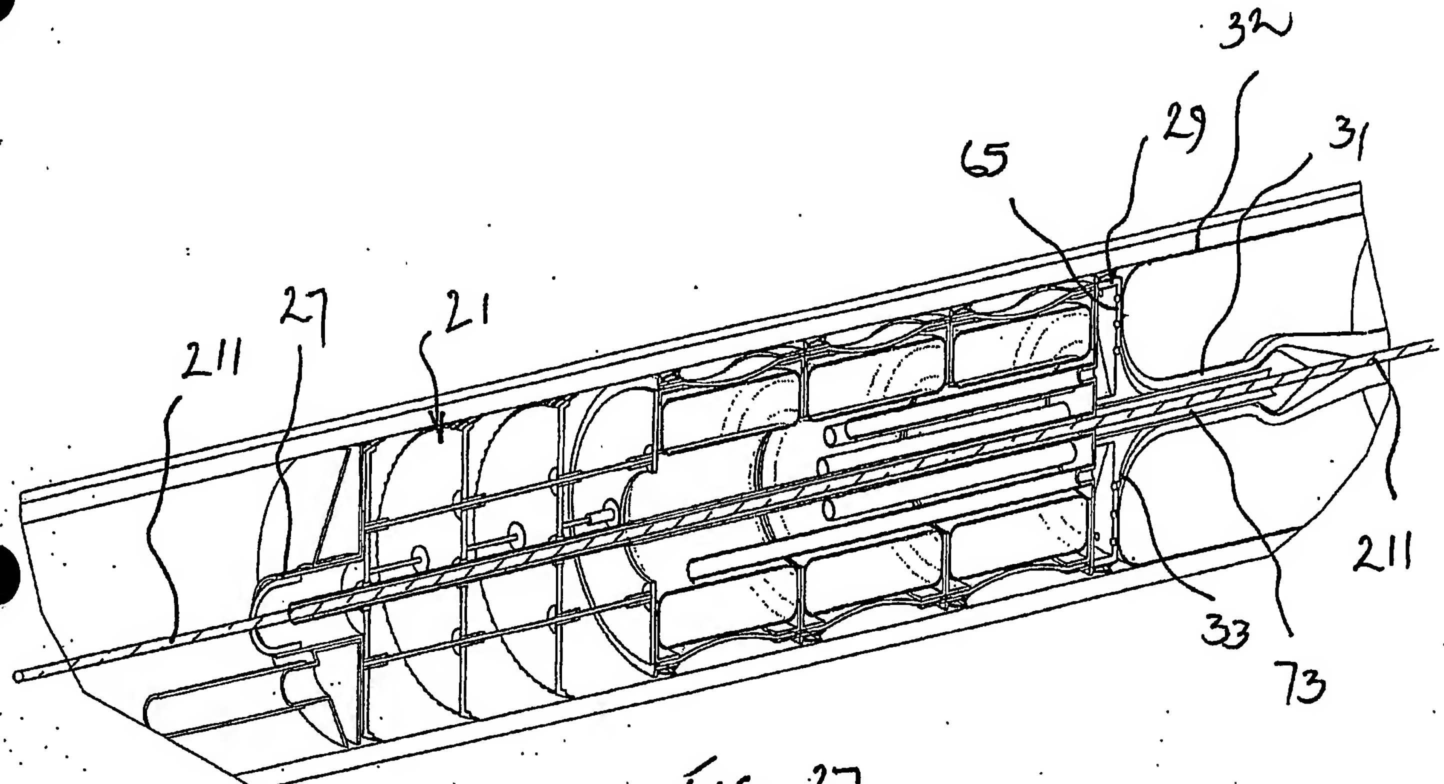


FIG. 27

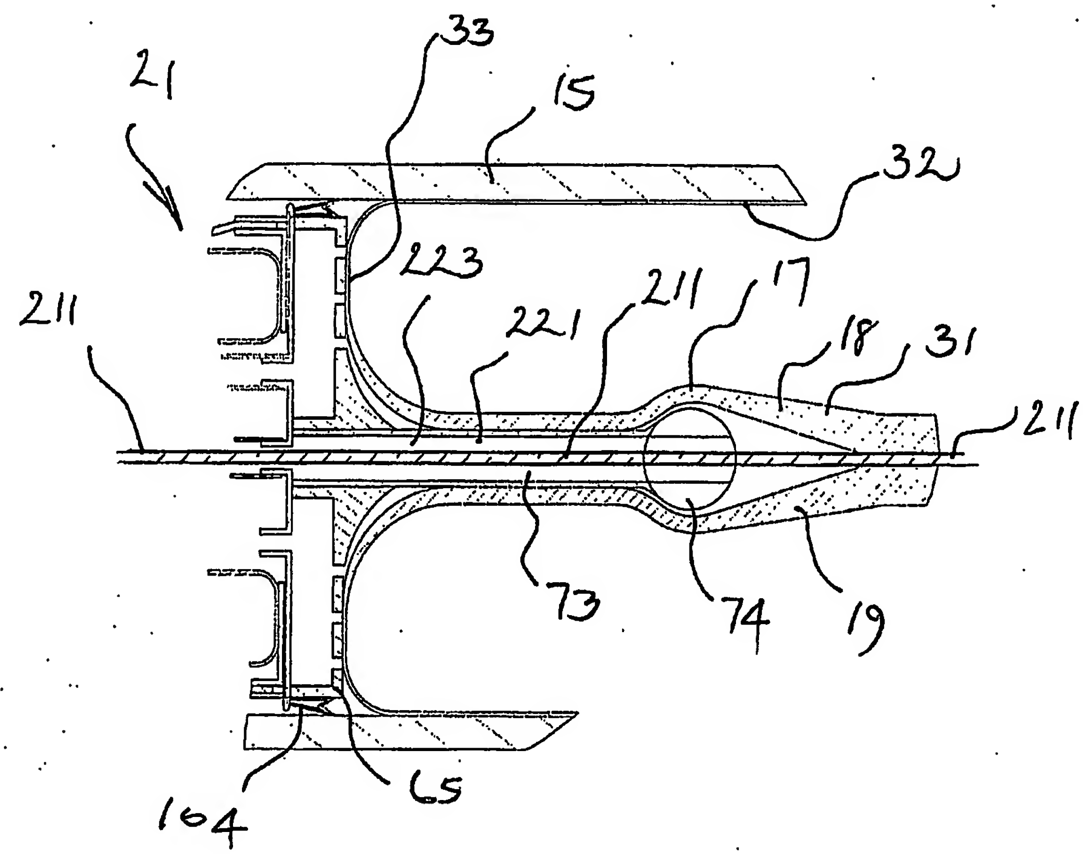


FIG. 28

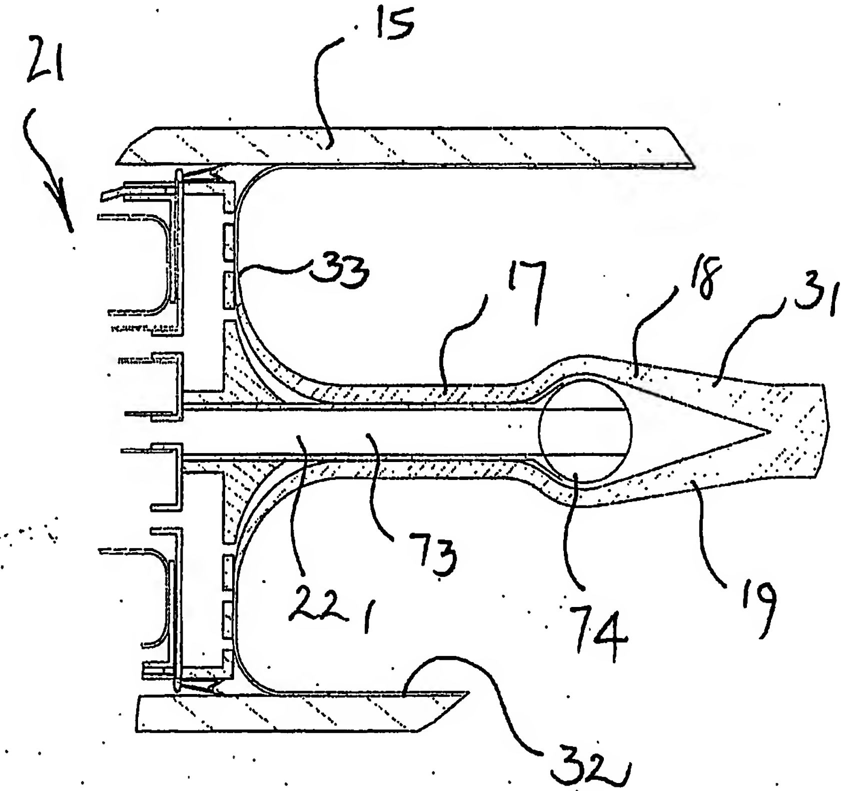


FIG. 29

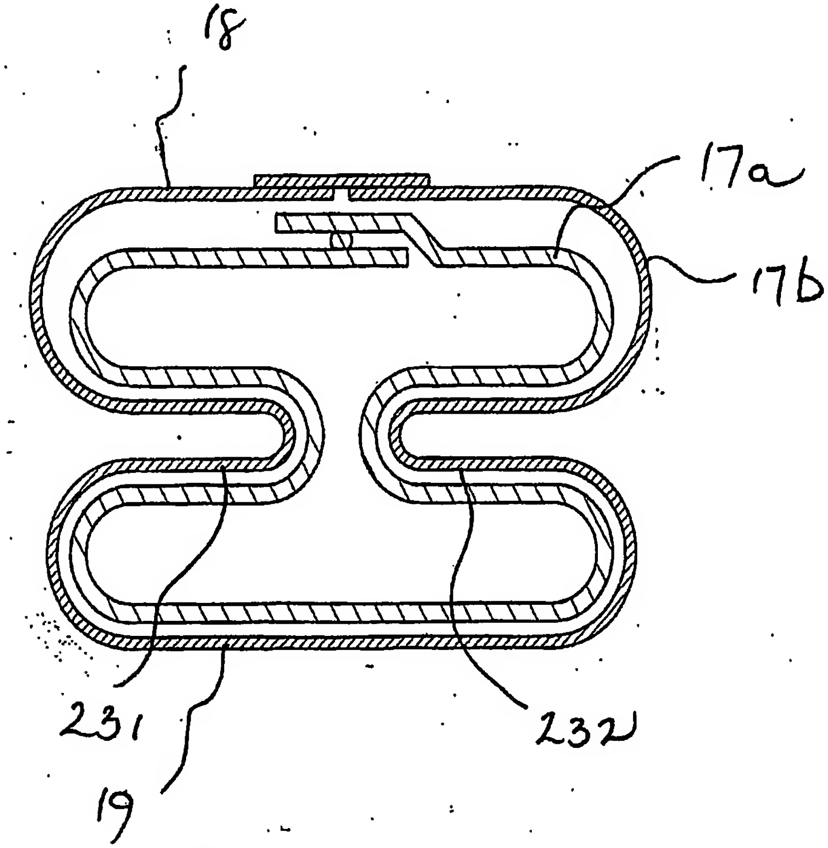


FIG. 30

Patern of eversion on "H" folded sock rope in centre each section of sock has about the same distance to travel and about the same angle

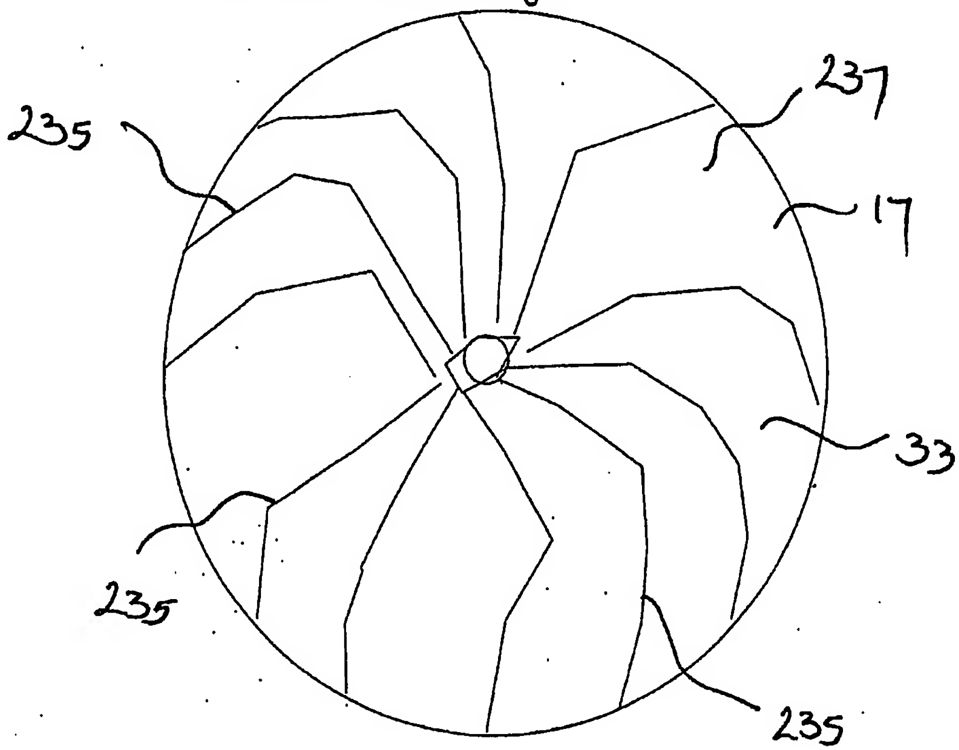


FIG. 31

Patern of eversion on standard sock note some sections of the soock move a long distance from centre to side other sections only have small movement on edges of fold and a steep angle of change.

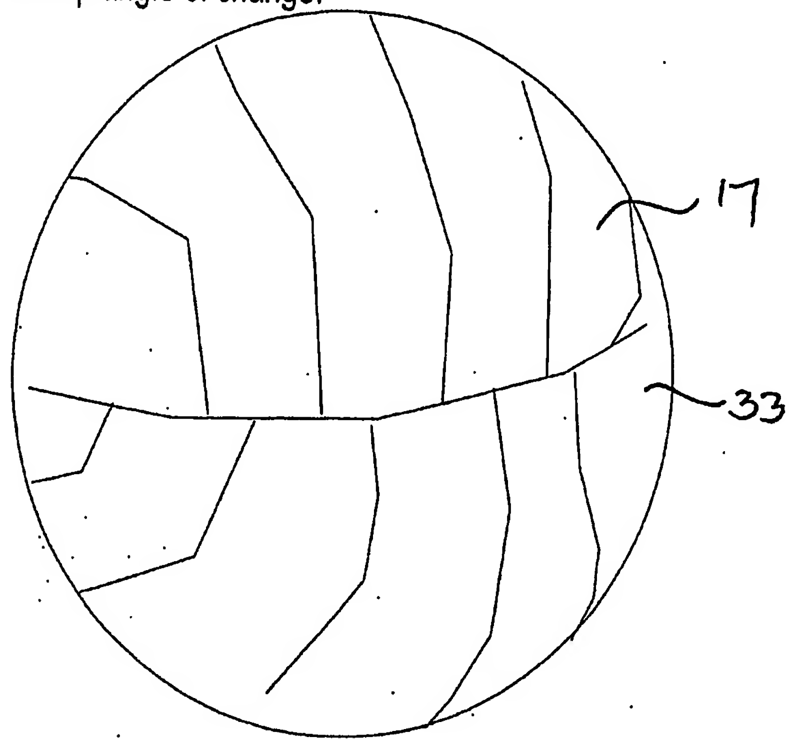


FIG. 32

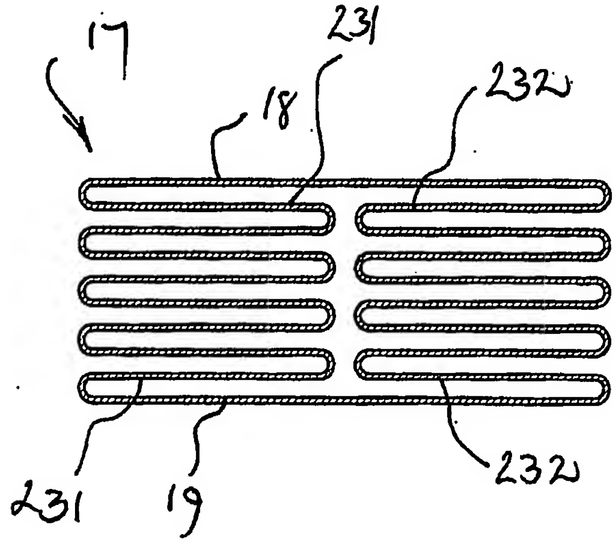


FIG. 33

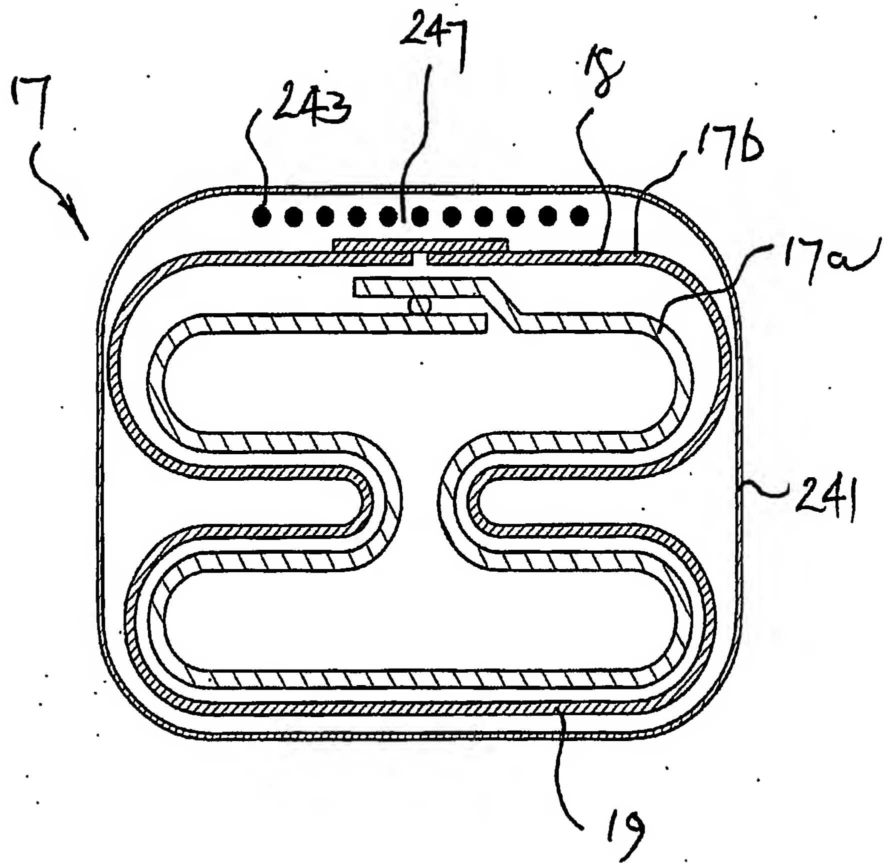


FIG. 34

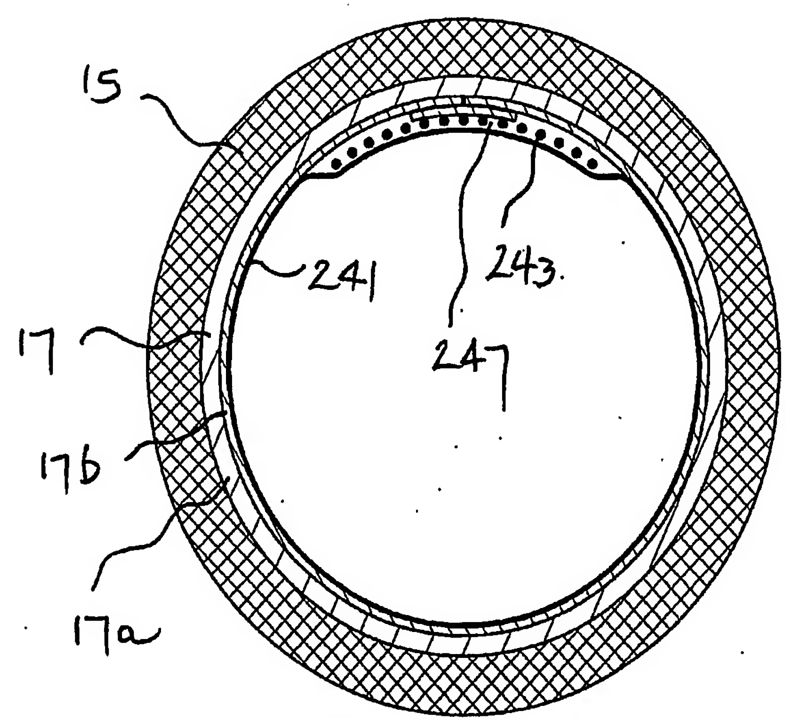


FIG. 35

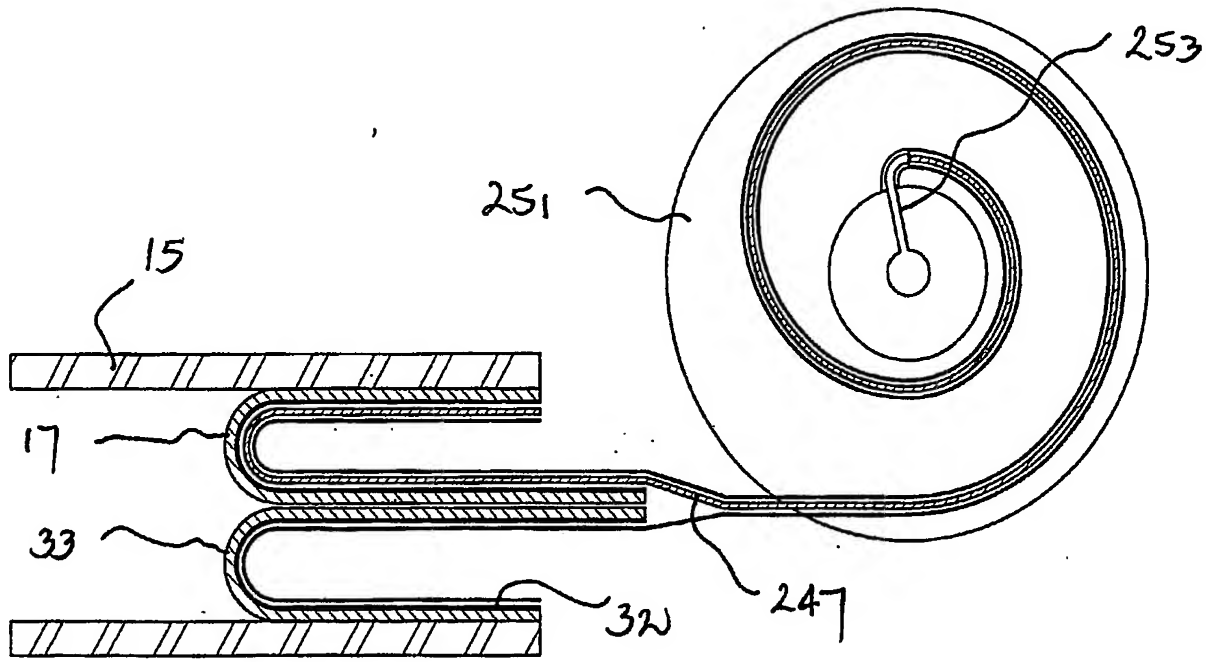


FIG. 36

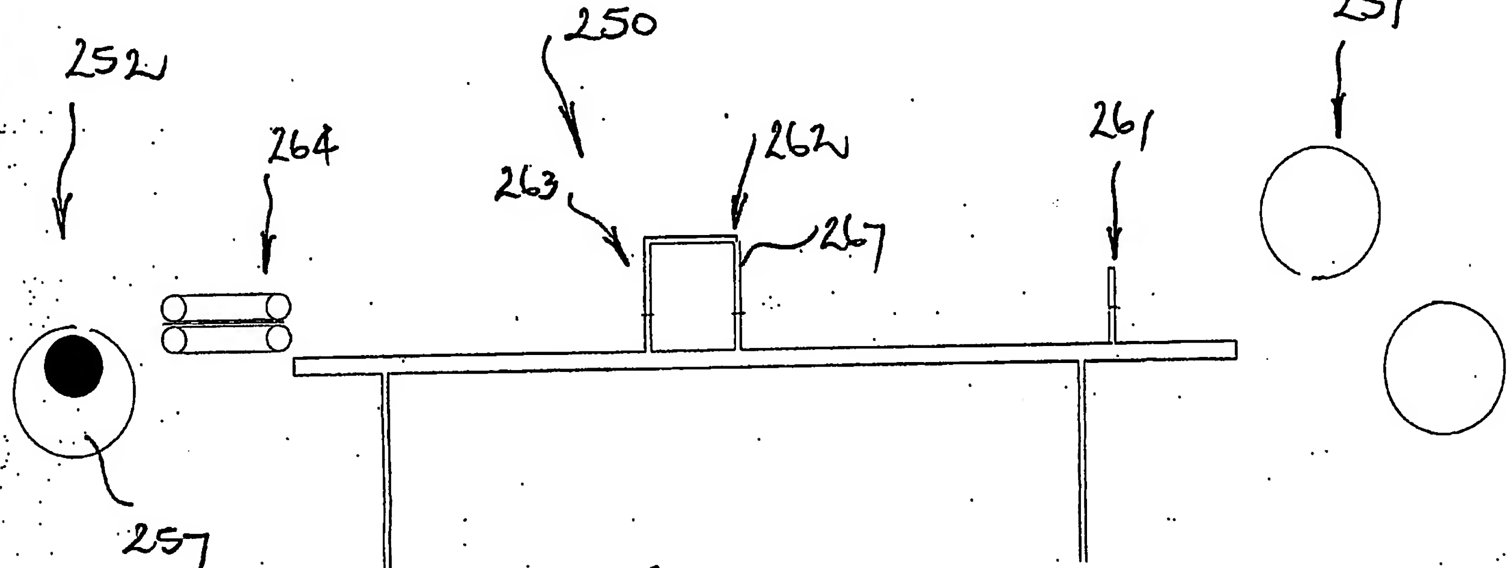


FIG. 37

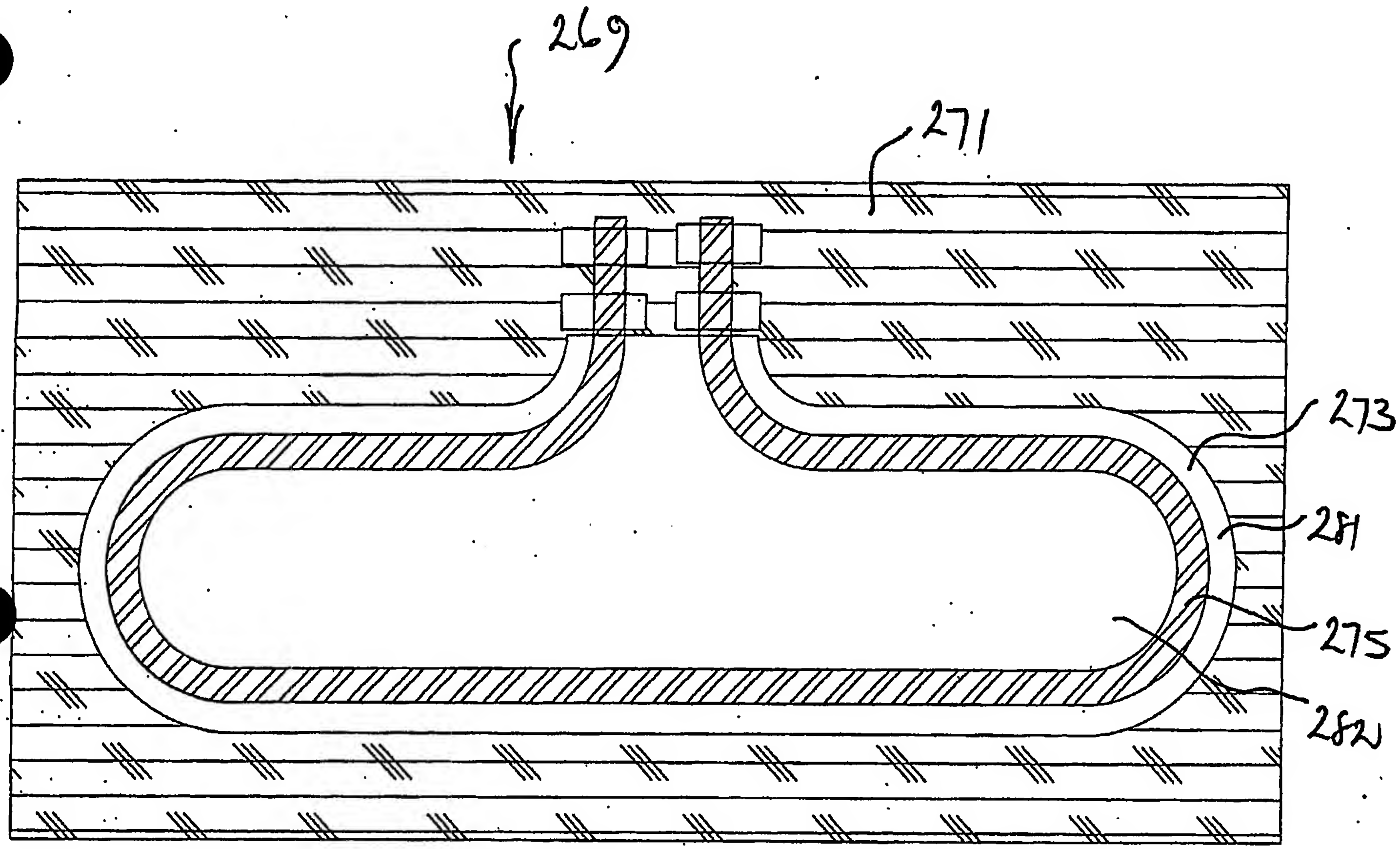
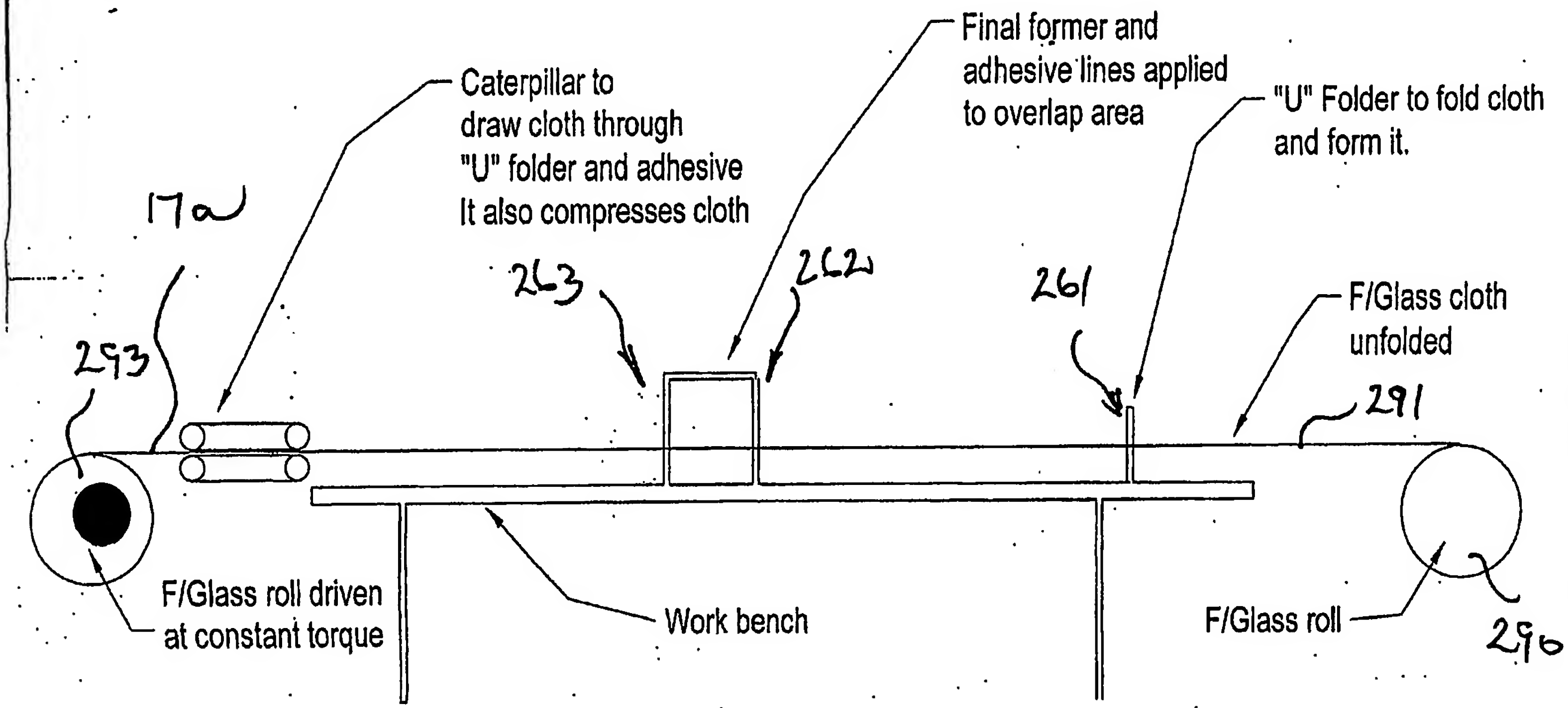


FIG. 38



17a
Caterpillar to
draw cloth through
"U" folder and adhesive
It also compresses cloth
Final former and
adhesive lines applied
to overlap area
"U" Folder to fold cloth
and form it.
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261
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unfolded
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F/Glass roll driven
at constant torque
Work bench
F/Glass roll
290

FIG. 39

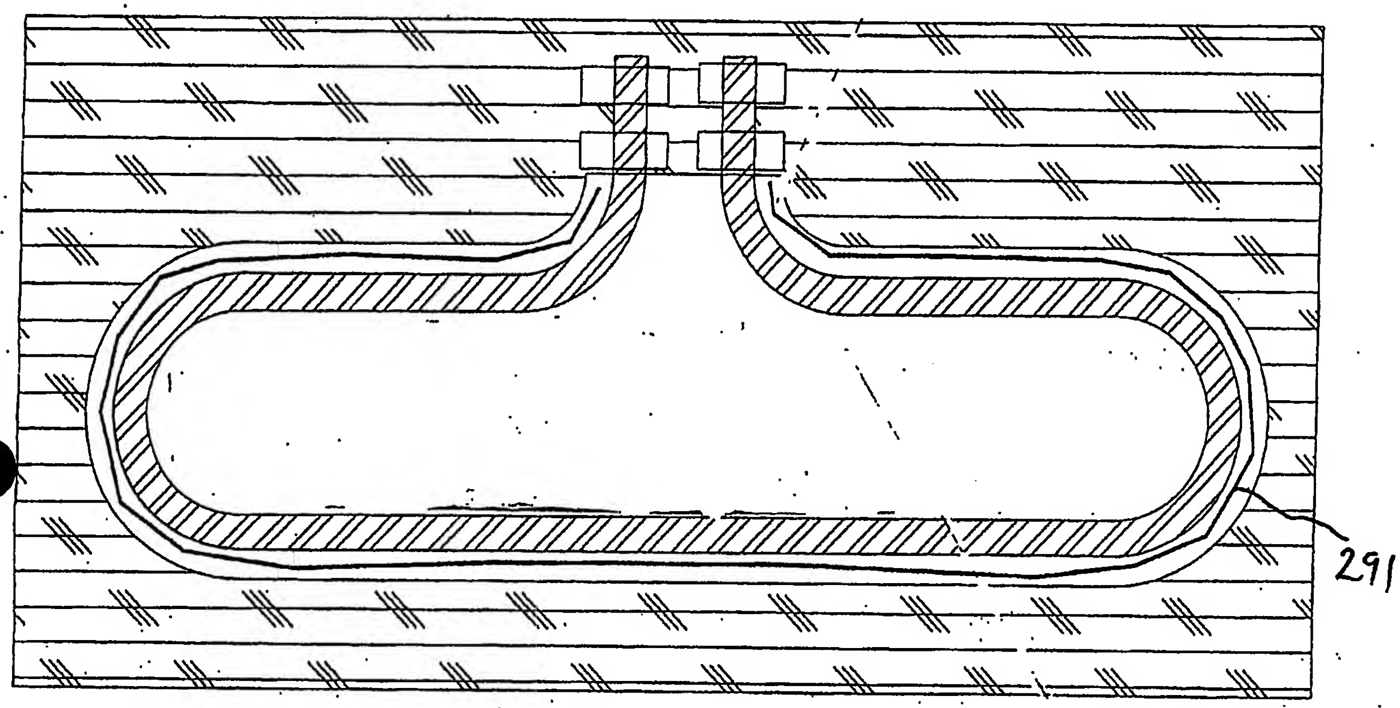


FIG. 40

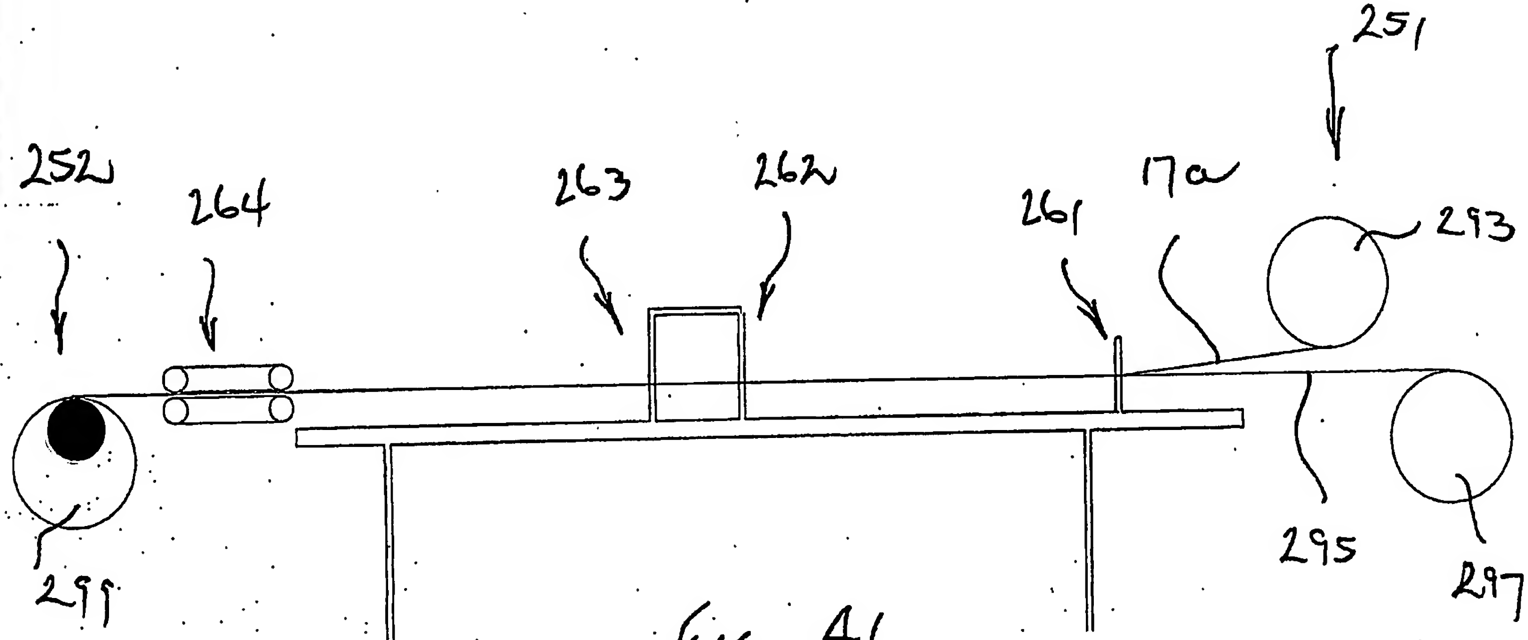
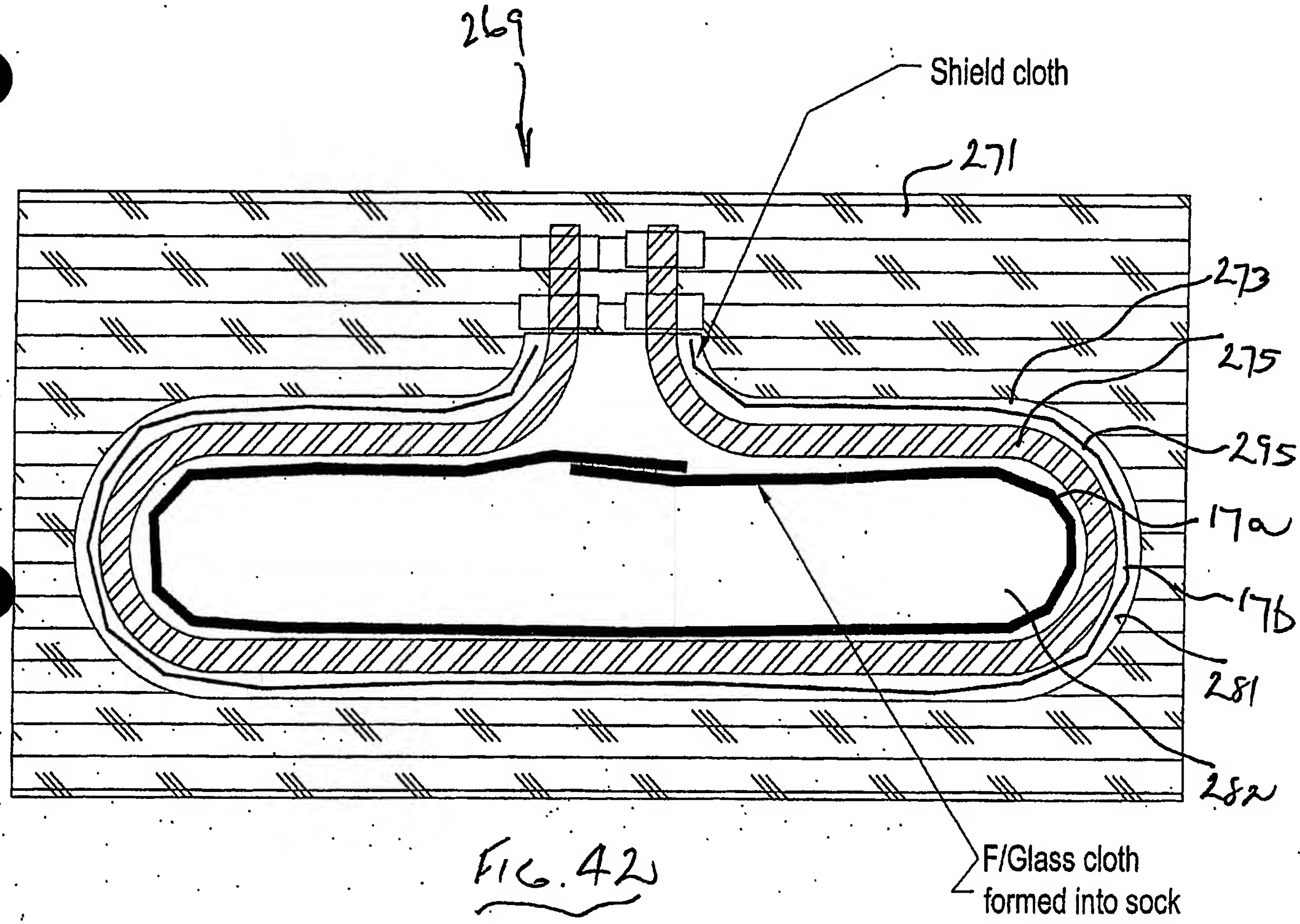


FIG. 41



269
Shield cloth
271
273
275
295
17a
17b
281
282
F/Glass cloth formed into sock

FIG. 42

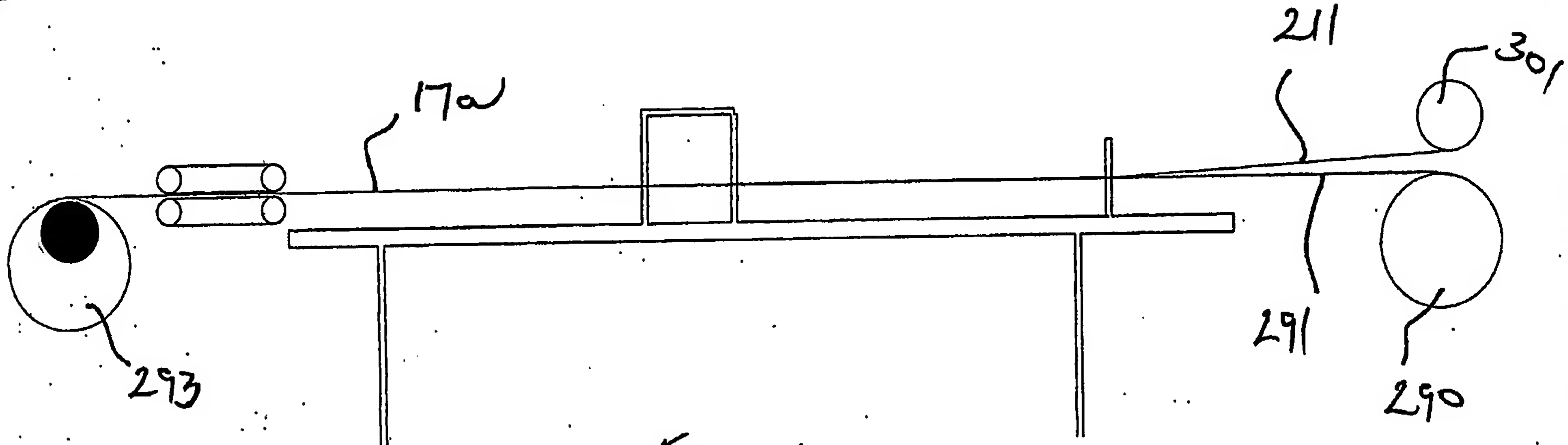


FIG. 43

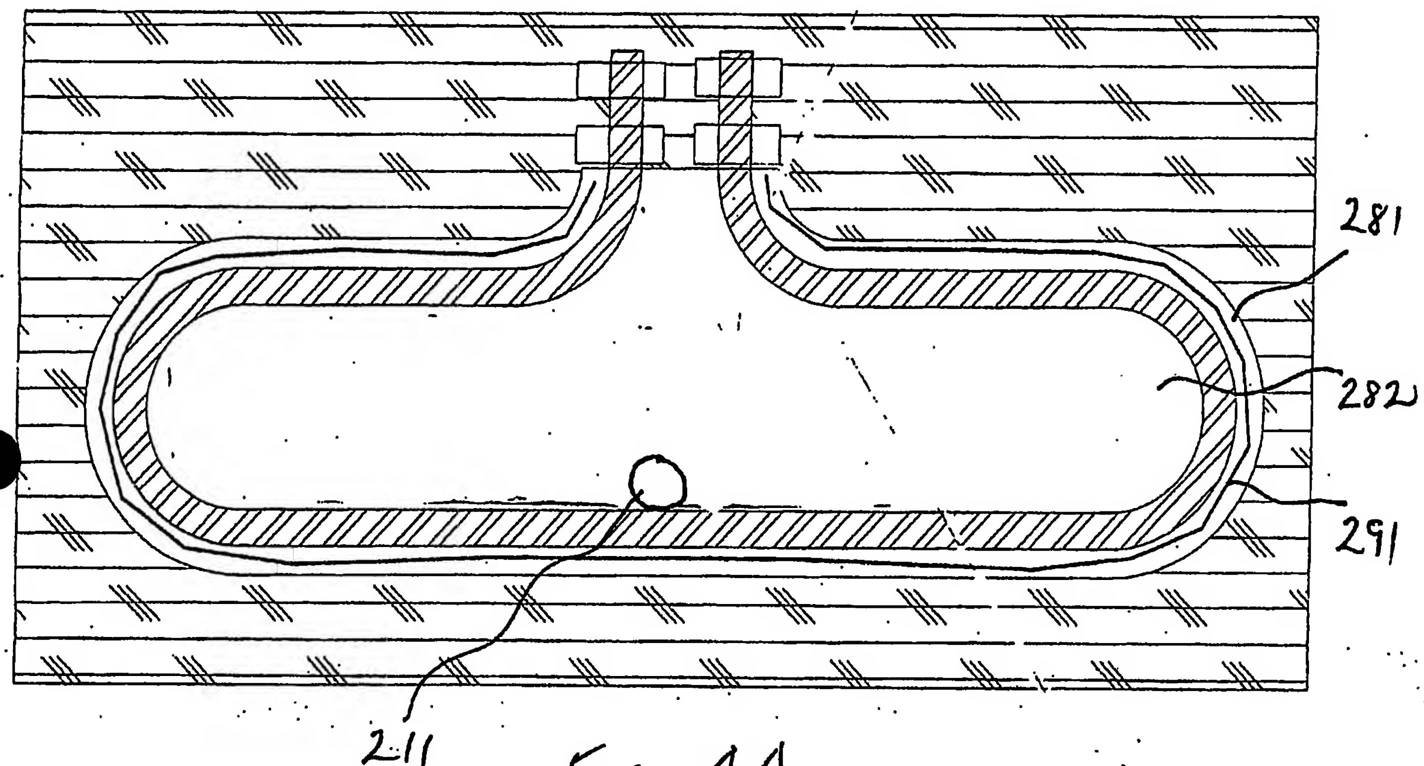


FIG. 44

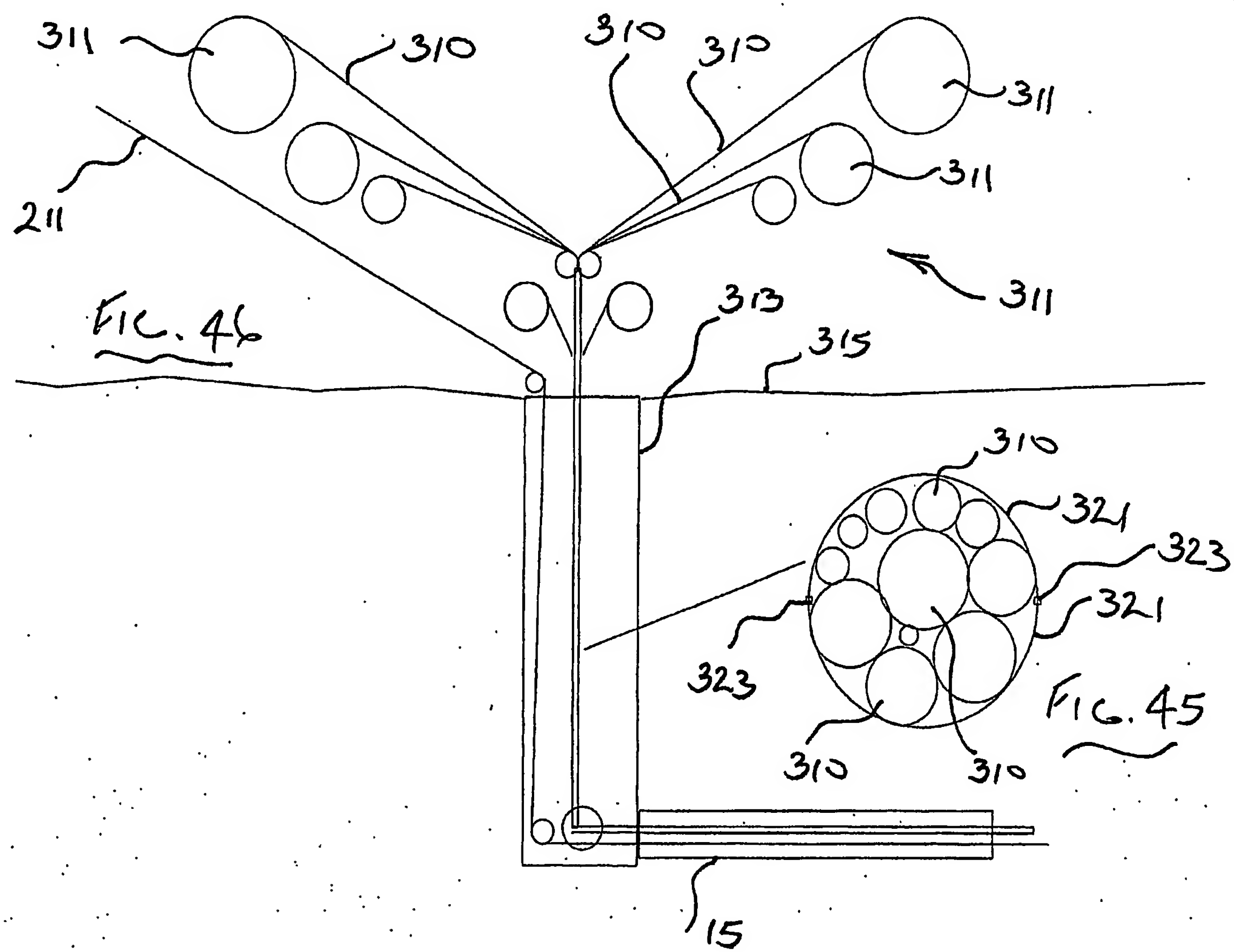

311
310
310
310
311
311
211
311
313
315
15
310
321
323
321
323
310
310

FIG. 46

FIG. 45